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THE TRANSATLANTIC RECORD WESTWARD was broken by the Hamburg-American Line steamer "Deutschland," which left Hamburg on Sept. 1 and reached New York on Sept. 6. Her time was 5 days, 11 hours and 54 minutes for the trip. This is 69 minutes less than the same vessel's previous best record, and 3 minutes less than the record of the new North German Lloyd steamer "Kronprinz Wilhelm." The daily runs of the "Deutschland" were: 417, 571, 578, 570, and 335 knots, or a total of 3,054 nautical miles at an average speed of 23.15 nautical miles per hour. This trip is the first one made by the "Deutschland" since July 2, when she left New York to receive a thorough overhauling.

A FAST LONG DISTANCE RAILWAY RUN was made on the Baltimore & Ohio R. R. on Sept. 6, when 128 miles were traveled in 125 minutes. The distance traversed was between Chicago Junction, O., and Garrett, Ind. According to the press dispatches a maximum speed of 85 miles an hour was reached in course of the run. Bursts of speed of 70 and 75 miles an hour were frequent. The train was made up of five cars, and was pulled by Engine No. 1,400, of the new Atlantic type, weighing 177,000 lbs. An extra large water tank helped in this remarkable performance, saving stops for water. From Garrett to Chicago another engine of the same make took the train. On this run a speed of 76 miles an hour was reached, and it is stated that the performance between Chicago Junction and Garrett could have been duplicated had the train not been blocked by a train ahead, to which it was running as a second section. This necessitated slowing down several times. The distance of 131 miles between Garrett, Ind., and South Chicago was, however, covered in 153 minutes, making the whole run of 259 miles in 278 minutes.

A DUPLEX COMPOUND ARTICULATED LOCOMOTIVE of the Mallet type (introduced a few years ago by Mr. Mallet, of Paris, France,) has been ordered for the heavy freight service of the mountain divisions of the Baltimore & Ohio R. R., and the contract has been given to the American Locomotive Co. Under the firebox and cab are six coupled wheels driven by the high-pressure cylinders, which are put in front of the leading wheel, the rear wheels being the main drivers. The low-pressure cylinders are mounted on the frames of a six-wheeled swiveling steam truck under the boiler and firebox. The principal dimensions are as follows:

Wheels	4 ft. 8 ins.
Wheelbase of each set of 3 axles	10 " 0 "
Wheelbase, total	30 " 6 "
Weight of engine	285,000 lbs.
Weight of eng. and tender	415,000 lbs.
Cylinders, h. p. (2)	20 x 32 ins.
Cylinders, l. p. (2)	32 x 32 ins.
Valve gear	Walschaert type
Boiler, diameter	6 ft. 4 ins.
Boiler pressure	230 lbs.
Tubes, No. 376, diameter	2¼ ins.
Tubes, length	18 ft. 9 ins.
Heating surface, tubes	4,130 sq. ft.
Heating surface, firebox	190 " "
Heating surface, total	4,320 " "
Grate area	56 " "
Water in tender	7,000 gallons
Coal in tender	12 tons

TURBINE ENGINES FOR ONE OF THE NEW SCOUT ships are recommended by Rear-Admiral George W. Melville, and the Naval Board of Construction has approved the recommendation. Rear Admiral Melville says:

> I respectfully recommend that one of the new vessels of the navy of not more than 5,000 tons displacement, and preferably of the scout or very fast cruiser class, be fitted with steam turbines instead of reciprocating engines. My reasons for this recommendation are that the steam turbine has now passed beyond the experimental stage, and various vessels in which it has been fitted, particularly fast passenger steamers, have proved eminently successful.

He adds that the ability to use highly superheated steam, the few moving parts and the reduced engine room are in themselves sufficient reasons for extensive experiments with the steam turbine; and he favors the installation of such turbines in a small vessel, not because they may not prove efficient on a larger one, but because he believes that it is not a good policy to change the motive machinery in the larger ships until it has been shown by exhaustive trials on the smaller scout ships that it will be wise to make the change.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Southern Ry., near Yorkville, S. C., on Sept. 3. A passenger train broke through a trestle over a creek and six persons were killed.——A rear collision on the Pennsylvania R. R., at Ryde, Pa., caused the death of three men on Sept. 5. Several other train wrecks with fatal results are reported for the week.

SEVERAL SERIOUS ELECTRIC RAILWAY ACCIDENTS occurred during the past week. The worst of these was a butting collision between two cars on the New Hampshire Traction Co.'s electric railway, near Pelham, N. H., on Sept. 6. The accident occurred on a curve, when both cars were running at fair speed. Four persons were killed outright or died soon after, while several others were seriously injured. The collision is attributed to a mistake or misunderstanding in the orders given by the starter to the motorman of one of the two cars. A very similar accident occurred the day before on the Orange County Traction Co.'s line near Newburgh, N. Y., but fortunately no lives were lost.

CURTAIN WALLS OF EXPANDED METAL and plaster have recently been used in a number of factories to prevent the rapid spread of flame. At the Hamilton, Ont., works of the Deering Harvester Co. these fire curtains were employed in the following form: The building was of brick with timber roof trusses resting on the side walls. The trusses were furred and lathed on both sides with expanded metal, the furring and lathing being carried up so as to project about 3 ft. above the roof, and then plastered with 1 in. of cement mortar.

INQUIRY INTO THE PARIS SUBWAY ACCIDENT of Aug. 10 is being conducted with much secrecy, according to our European contemporaries. Some few facts have, however, leaked out and such of these as are of general interest are given. The Prefect of Police has ordered the company to carry out the following improvements: In each station and in the tunnel are to be placed lamps connected with the city mains and independent of the Metropolitan railway current. Fire plugs are to be placed in each station and so arranged that the turning on of the water will automatically cut off the current. Fire alarms are to be placed in the tunnel at intervals and each station is to be connected by telephone with the nearest fire station. A staircase is to be built at each end of the station platforms. M. André Berthelot, managing director of the Metropolitan Company, states that the company is considering various devices for isolating the electrical mechanism from the vehicles. It is also intended to construct the rolling stock with fireproof material. The most important feature of the inquiry, however, is that relating to the electrical equipment of the line. It is generally recognized that the live rail on the track is a danger in the event of passengers being required to get out of a disabled train in the tunnel, and it is therefore proposed to place it overhead; but further evidence has been received which points to the possibility of the electrical equipment being changed altogether, as the Commission appears to have been greatly impressed by the explanations which were given concerning the magnetic system of traction which has been experimented with for several months past at the works of Dutuit, of Charleroi. In this system electro-magnets are placed at certain distances between the rails, and the coach is drawn from one to the other, each being demagnetized as the coach passes over it. The system is said to have given such excellent results that it is regarded in Belgium with considerable favor, and the Paris authorities intend fully to investigate it, with a view of seeing whether it can be satisfactorily employed on the Metropolitan.

A CIVIL SERVICE EXAMINATION will be held Oct. 21 and 22 by the United States Civil Service Commission to secure eligibles from which to make certification to fill 14 vacancies in the position of civil engineer in the Philippine service, at salaries ranging from $1,400 to $1,800 per annum. The subjects upon which the applicants will be examined will be as follows: Pure and applied mathematics (elementary problems and mensuration, solution of plane triangles, and theoretical and applied mechanics, involving a fair knowledge of pure mathematics up to and including calculus); use and care of field instruments (comprising transit, including stadia work, level, plane table, rods, chain, tape, current, meters, etc.); theory and practice of surveying (comprising surveying, leveling and other field work required in civil engineering); design and construction (involving elementary knowledge of designing and constructing highways, railroads, dams, retaining walls, foundation work, trusses, etc.), and educational training and experience.

A DAM ACROSS THE TUNGRAHBADA RIVER in India is proposed by British engineers for the purpose of irrigation. The dam is to be built near Hospet, which is near the center of the southern portion of the Indian peninsula, and will be nearly a mile long and 150 ft. high. It will form a lake 40 miles long, with an area of 150 square miles, and will impound 200,000,000,000 cu. ft. of water. As compared with the Assouan dam, the Tungrahbada dam will be about ¼-mile shorter, but about twice as high, and will impound six times the amount of water.

THE LONDON TRAFFIC COMMISSION, which is investigating the local transportation problem in Greater London, will send six of its members to America to study street railway facilities here the latter part of September. Mr. Lynden L. Macassey is secretary of the commission, and will sail on Sept. 18, in advance of visiting members. Among the latter will be Mr. Geo. Gibb, General Manager of the North-Eastern Ry.

THE CALUMET DRAINAGE CANAL as an auxiliary to the Chicago main drainage canal, is supported by Mr. Isham Randolph, Chief Engineer of the Sanitary District, as against the utilization of the Illinois & Michigan canal as suggested by Mr. L. E. Cooley (Eng. News, Aug. 27). Mr. Randolph points out that the great volume of filth discharged from the Calumet River enters the lake at a point only 3⅝ miles south of the outer intake of the Hyde Park water-works, which supplies some 575,000 people. The reversal of flow of this river, in the same way as that of the Chicago River has already been reversed, is a matter of great importance. Mr. Cooley, however, considers that the condition of the north branch of the Chicago River is very much worse than that of the Calumet River, and that the system of intercepting sewers will in a large measure check the pollution of the lake.

A LARGE FACTORY BUILDING built of concrete steel throughout is to be erected at Cincinnati for the American Book Co. The building will be a five-story structure covering an area 356 x 150 ft., and will be designed for floor loads of 150 lbs. per sq. ft. The architects of the building are Messrs. Elzner & Anderson and the building will be erected by the Ferro Concrete Construction Co., of Cincinnati. The same firm built the Ingalls Building, described and illustrated in our issue of July 30.

THE WATER POWER AVAILABLE in the states of North Carolina, South Carolina, Georgia, Alabama, Tennessee, Mississippi, and Florida is being investigated by the U. S. Geological Survey. The highest fall with a large volume of water is at Tallulah Falls on Tallulah River, where a head of 525 ft. can be utilized cheaply by building a canal and a dam. At Big Muscle Shoals, on the Tennessee River, 100,000 HP. can be developed.

AUTHORIZATION OF A COMPETING ELECTRIC light plant at Haverhill, Mass., has been refused by the Massachusetts Gas & Electric Light Commission. The refusal is based on the general grounds that (1) the proposed competing company merely offers a reduction in the rates for public lighting, without any assurances that the rates for commercial lighting will be any lower than those charged by the old company; and (2) the citizens and taxpayers would eventually be called upon to foot the bills for a needless duplication of plant.

EARLY IRON BUILDING CONSTRUCTION.

In our issue of June 25, 1903, we made brief note of the demolition of an old building in New York city which contained some exceedingly interesting floor framing. Following out our promise given in that note, we present herewith some details of this framing.

The building in question, known as the Bank of the State of New York building, occupied the northwest corner of William St. and Exchange Place, extending about 40 ft. north on William St. and about 90 ft. west on Exchange Place. It was five stories high above the ground, and had in addition a basement (half above ground) and a low attic story. The outside walls were of brick, with marble facing on the street frontages. The floors were of full iron framing, with a sheet-iron trough-plate flooring leveled up with concrete to support wooden floor boarding.

FIG. 1. VIEW SHOWING TYPICAL FLOOR CONSTRUCTION, OLD BANK OF THE STATE OF NEW YORK BUILDING.

The floor framing was entirely of wrought iron. The building was erected during the years 1855 or 1856. At that time riveted wrought-iron construction was in its earliest infancy, hardly more than a thing of the future. Rolled wrought-iron I-beams had only just been invented. Principally for this reason the framing used in this building is of great interest. The general arrangement of the framing is quite modern; the photograph, Fig. 1, which is a view taken on the fourth floor during the work of demolition, does not even remotely suggest the age of the structure. Looking more closely at the component parts of the iron work, however, we find a riveted girder construction which passed out of use probably over forty years ago, after being current for a decade at the least. It is, according to our present knowledge of beams, wholly inadequate and uneconomical, and in particular the long span for which it was employed in this building adds to the antiquarian interest which it possesses. Equal interest attaches to the detail construction of the floor beams or joists, which, though built before the general introduction of the rolled I-beam, possess its form and its economy of metal. Beams of the type found here were probably never widely used. We are not aware of any earlier use than in the Bank of the State of New York, and it is certain that the I-beam a few years later displaced them from the list of structural iron forms. It is probable that the beams in this building are the sole surviving examples of this style of wrought-iron beam. Who was its originator, and whether this form of beam was first used in the building in question, we have been unable to learn. At any rate, these old beams of the 50's represent a most excellent adaptation of wrought iron to the purposes they were intended to serve.

The girders and the beams are the principal items of interest in this building. The troughing floor-plate, well shown in Fig. 1, is of less antiquarian interest, since it has come down even to the present time, though in other forms than the simple V-shaped corrugation. We have already referred to the modern character which the general arrangement of the floor bears. This will be further evident from the more technical description below, following which we show sketches of the details of the ironwork.

GENERAL CONSTRUCTION.

There were no interior columns in this building, with the unimportant exception of a series of light cast-iron columns supporting a trimmer-girder at the edge of the stairwell on each floor. Riveted iron plate-girders 18 ins. deep, of I-shaped cross-section, spanned from wall to wall transversely of the building, about 35 ft. in the clear; they were spaced about 8½ ft. apart and formed the main floor supports. Transversely between these girders and resting on their bottom flanges, were iron beams, spaced about 5½ ft. apart. These beams were 10 ins. deep, of I-shaped section, and were made up of thin plate iron. In some cases they were fastened to the girders by two small iron rivets through the bottom flange.

Corrugated floor-plate of thin wrought-iron was laid over the 10-in. beams, the corrugations running transversely to the beams, i. e., parallel with the main girders, thus spanning the space of 5½ ft. between the beams. The depth of corrugation was about 6 ins.

The floor was leveled up with concrete, about 2 ins. deep over the tops of the corrugations; wooden flooring was laid on this concrete filling and nailed to strips embedded in the concrete. The ceilings were of lath and plaster, fastened to studding framed closely arouud the ironwork. Some of this studding can be seen in Fig. 1.

DETAILS OF IRONWORK.

FLOOR-PLATE.—A sketch, with dimensions, of the typical arrangement of girders, beams and trough-plate flooring, is shown in Fig. 2. Proceeding in our description of details from the top downward, we may mention that the trough-plate, of 1-16-in. iron, appears to have been laid in widths of about 24 ins. The joint was made by lapping the edges about 1½ ins. and pinning the two sheets together by a line of rivets. Such a joint is indicated in Fig. 2. The metal appears to have had two coats of paint, as did also the other ironwork. Its present condition is in general excellent, as will be noted later. The manner in which the edge of the plate was fastened to the top flange of the girders is also shown in Fig. 2. Apparently small rivets (about ¼-in.) were driven into holes drilled part way through the flange-plate of the girder, and were riveted over the trough-plate; these rivets, or rather plugs, were spaced 6 ins. apart. They were seated so firmly that in removing the floor-plate the latter tore away without bringing the plugs out. While the plate was in all cases fastened to the main girders, in the manner described, only occasional cases were to be found where the troughing was fastened to the floor joists. In these cases a rivet passed up through the top flange of the joist at the low point of the troughing and bore a wrought-iron washer over the troughing, the rivet being flattened down over the washer to form a head. Some of the floor joists taken from the building showed these rivet fastenings regularly every 12 ins. in the top flange; in general, however, the trough-plate merely rested on the beams, without any fastening.

FLOOR BEAMS.—The construction of the joists or floor beams is also shown in Fig. 2. An upper and a lower flange-plate, each 4 ins. wide by ⅛-in. thick, are united by two web-plates 1-16-in. thick, bent outward horizontally at top and bottom, to form an I-shaped section 10 ins. deep. The web-plates are held together in close contact by two rivets every 6 ins. in the length of the beam. Virtually a single web is thus formed. The flange-plates are fastened to the horizontal edges of the web-plates by one row of rivets in each edge of each flange. The rivet-spacing in these flanges varies between about 3½ ins. and 6 ins., the longer spacing being more common. As was stated above, the beams span about 8½ ft., and are spaced 5½ to 6 ft. apart. It would seem as though the form on which the web-plates were bent was only 7 ft. long, for all the joists show a lapped splice in the web-plates near one end, as is shown in the sketch Fig. 2, the shorter section of web being 24 ins. long and lapping 6 ins. over the other section. Where the beams rested on the lower flange of the girders they were in some cases fastened down by two iron plugs, 5-16-in. in diameter, driven down into holes in the girder-flange and riveted over on top.

The beams as described, with ⅛-in. flange-plate and two 1-16-in. web-plates, were used throughout the building as the regular floor joists. At one or two special locations, however, heavier beams of the same general type were used. These were in all respects identical with the beams shown in Fig. 2, except that their flange-plates were 4 × ¼-in. instead of 4 × ⅛-in. metal.

RIVETED GIRDERS.—While the floor beams may possess the greater historical importance, the main girders offer the larger number of individual features of interest. Their typical construction is exhibited in the sketch Fig. 3, which may be referred to the sketch Fig. 2 and the view Fig. 1.

The girders are 18 ins. deep, and, as was previously noted, they span about 35 ft. in the clear, the ends resting in the northerly and southerly walls of the building. They are composed of two vertical web-plates, usually ¼-in. thick, and flanges made up each of a single plate, usually 8 × ¾ ins. in section. The connection between web and flanges is made not by angles, but by vertical straps or stiffener bars riveted between the two web-plates and engaging the flanges by means of tenons fitting into rectangular holes punched through the flange-plates. These stiffener bars are uniformly 3 × ¾ ins. in size and have their ends reduced in width to form a rectangular tenon 1½ ins. wide by ¾-in. thick; the tenons are riveted over after passing through the flange-plates. The web-plates are riveted to the stiffeners by three rivets (about ⅝-in.) spaced vertically 6 to 7 ins. apart.

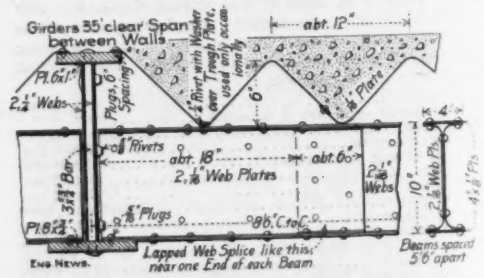


Fig. 2. Part Section of Floor, Showing Construction.

Most of these girders were spliced in both web and flanges. The flange splices were made by a cover plate, usually 8 × 1 in. in section, which was connected to the flange by six or eight rivets on each side of the joint. Occasionally a greater number of rivets was used, and in general the rivet spacing was somewhat irregular; the number of rivets on the two sides of the joint was often unequal, as six rivets on one side to eight

on the other. The web was spliced either by a butt-joint with coverplate on the outside of each web-plate, or by a lap-joint. The number and spacing of the rivets was irregular; about 12 to 15 rivets each side of the joint in each web-plate is a fair average. It is to be noted especially that there was no filler between the two web-plates at the splices, but each plate was spliced separately, the rivets passing through that web only. This construction will be more clearly understood by reference to the horizontal sections of the two kinds of web-splices, in Fig. 3. In some cases a stiffener bar was located in the

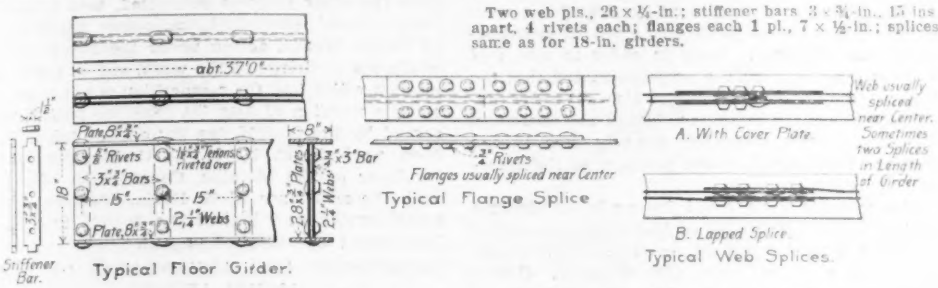


FIG. 3. PART SKETCH OF TYPICAL FLOOR GIRDER, SHOWING TWO-WEB METHOD OF BUILDING RIVETED GIRDERS.

splice, immediately under the joints in the web-plates, as in the splice shown at A, Fig. 3.

The character of the riveting was, as may be gathered from the sketches, hardly what would be considered permissible at the present time. The rivets as supplied had panheads of ample proportions, but the other head, produced apparently by hand riveting in all cases, was in general an irregular flat button. In the web-splices this flat head was in the space between the two webs, the ¾-in. space being sufficient to allow the heads of rivets in the two web-plates to come opposite each other without interfering. The heads formed by riveting over the tenons at the ends of the stiffener bars in the web were also merely mushroom-like flattenings of irregular outline.

The rivet-holes were in all cases punched, except, probably, in 1-in. metal, where they seem to have been drilled. The rectangular (1½ × ¾-in.) holes in the flange-plates, engaging the tenons of the stiffener bars, were also punched.*

While most of the 18-in. girders were of the dimensions and make-up noted above, there were a number of apparently irregular exceptions. The following are examples:

(1) Two web pls., 16½ × ⅜-in.; upper flange, 6 × 1-in.; lower flange, 8 × ¾-in.; stiffener bars, 3 × ¾-in.

(2) Two web pls., 15 × ⅜-in.; stiffener bars, 3 × ¾-in.; upper flange, 7 × 1-in.; splice 8 rivets on one side, 6 rivets other side; lower flange 7 × 1-in.; splice, 16 rivets each side of joint.

(3) Two web pls., 17 × ¼-in.; stiffener bars, 3 × ¾-in.; flanges, each, 6 × 1-in., full length (no splice); two 2¼ × 2¼ × ¼-in. angles under each flange.

The last example is noteworthy on account of the angles used under the flange plates. These angles were riveted through the webs only, however.

A few girders of the same general construction as those described, but 27 ins. deep, were also found. These formed the main girders of the uppermost or roof tier. Their make-up varied somewhat, but averaged about as follows:

Two web pls., 26 × ½-in.; stiffener bars, 3 × ¾-in., 15 ins. apart, 4 rivets each; flanges each 1 pl., 7 × ½-in.; splices same as for 18-in. girders.

From this, in conjunction with Fig. 3, the construction of these extra-deep girders will be fully apparent. A noteworthy additional fact, however, is that one of these girders had at one end a pair of end-connection angles, riveted through the double web and intervening stiffener bar with seven rivets. These angles were 4 × 4 × ½-in. angles. Their outstanding legs were punched the same as the other leg, but as this end of the girder was embedded in a masonry wall, the purpose of the angles in this isolated case is not clear. The occurrence is of interest as showing that angles as large as 4-in. leg and ½-in. metal were to be had at the time the girders were built.

SINGLE-WEB GIRDERS.—A small number of minor girders in this building are important as exhibiting a distinct variation in the method of riveted-girder construction used for the main girders and described above. The variation consists in using a single web-plate, held by stiffener-bars placed on both sides of the web-plate. It will be clear that this method of construction would find convenient application in the case of small girders, or where light loads were to be carried. Accordingly we find it used for trimmer beams and similar lightly-loaded beams. As a typical example we show the drawing, Fig. 4, representing a trimmer beam 18 ins. deep framed between the main girders. The web, a 17½ × 3-16-in. plate, is central to the two flanges, which are each one plate 4 × ⅜-in. The web stiffener-bars are 1½ × ⅜-in. bars spaced 12 ins. apart alternately on opposite sides of the web. The tenons on the ends of these bars are the full size of the bar. The beams of this construction were all of such length that both web and flanges could be made of a single length, so that splices need not be considered. The beams similar to that shown in Fig. 4 have angle framing-connections at the ends, of 1⅝ or 2¼-in. angles, 3-16 or ¼-in. thick, with a very heavy fillet at the root; the web of the beam is coped for the flanges of the main girders.

A longer but shallower girder of the same type, about 14½ ft. long, had 3 × ¾-in. stiffener-bars. This beam was peculiar in that one flange was 4 × ½-in., while the other was 7 × ¾-in.; the web was one 12 × ⅜-in. plate. Web and flanges were full length, no splices. This girder was without end fittings.

CONDITION OF IRONWORK.—All of the ironwork appears to have had two coats of metallic paint, probably iron oxide. The condition of this paint covering, and of the ironwork in general, at the time of taking down the building, was excellent. Rust, where it was to be found at all, was only incidental, in small patches here and there; but entire girders could be found with practically no spots of rust whatever. It is to be noted that both girders and beams (joists) were surrounded by an air-space, and the lower side

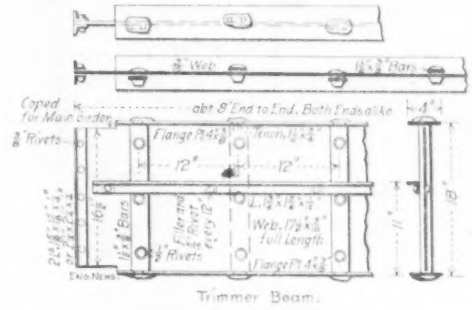


Fig. 4. Part Sketch of Trimmer Beam, Showing Single-Web Method of Building Riveted Girders.

of the trough-plate flooring also faced this air-space. The beams, with their thinner metal and poorer painting (in some cases, at least), showed more rust than the girders. The latter were practically unaffected. As good an illustration of this as we could give is afforded by the photograph* Fig. 5 of some of the girders in the first floor. Toward the right may be seen the builders' name, "J. B. & W. W. Cornell, 143 Centre St.," painted in white on the brown oxide paint of the girders, 53 years ago. The even shade of color over the surface of the girders is an indication of the first-class condition of the ironwork throughout the building.

We have already stated that this building was erected at least as early as the middle of the 50's, for the Bank of the State of New York, and that the ironwork was built by J. B. & W. W. Cornell, of 143 Centre St., which firm still exists under the name of J. B. & J. M. Cornell Co., at 26th St. and Eleventh Ave., New York City. It remains to add that the architect of the building was Mr. James Renwick, the designer of Grace Church and St. Patrick's Cathedral in New York and other noted buildings, who was then in the middle of his career.

The work of removing the building was done by the New York House Wrecking Co., of 514 E. 23d St., New York. A modern steel-skeleton building, 25 stories high, is now being erected on the site by the Thompson-Starrett Co., of 51 Wall St., New York.

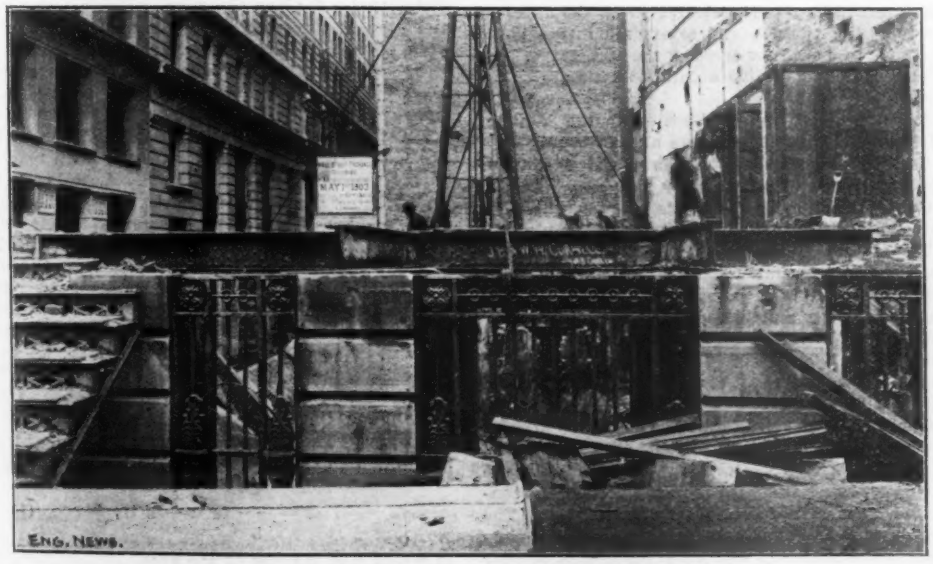


FIG. 5. VIEW OF GIRDERS IN FIRST FLOOR.

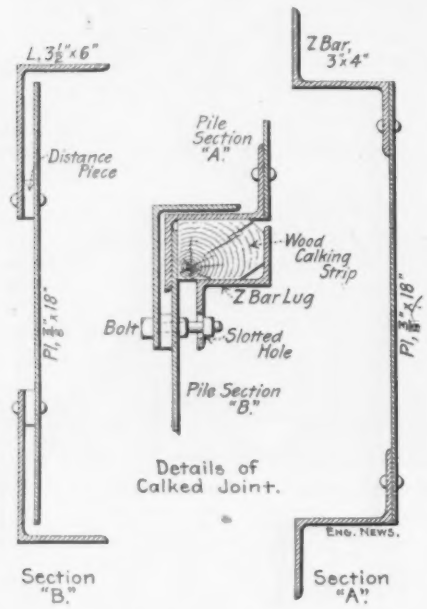
STEEL SHEET PILING.

Two different styles of steel sheeting or sheet piling for foundations, shaft lining, etc., have been described in our issues of July 11, 1903, and Feb. 14, 1901, while steel dock piles were illustrated in our issue of Aug. 22, 1901. Another recently invented form of steel sheet piling, in which plates

*According to Mr. J. M. Cornell this punching was doubtless done on some heavy Dix punching-presses, which are still in the possession of the firm of J. B. & J. M. Cornell Co., of New York, the successors of the firm which built the ironwork described

*For this photograph we are indebted to Mr. Geo. Simpson, Asst. Ch. Engr., of the Thompson-Starrett Co., New York.

and structural shapes are used, is shown in the accompanying illustration. The alternate piles are of different section. Those of section A are composed of a ⅝-in. plate 18 ins. wide with a Z-bar 3 × 4 ins. riveted along each edge. Those of section B are composed of a similar plate with an angle 6 × 3½ ins. riveted along each edge, the angles being separated from the plate by distance pieces so as to leave grooves for the outer flanges of the Z-bars of the adjacent piles. The plate in section A may be curved, and two piles of section B put together will form a corner. For special work the sizes given above may be varied. The



Steel Sheet Piling.
Henry Wittekind, Inventor.

piles are driven by an ordinary pile driver and can be pulled out when necessary.

To form a watertight joint, a calking strip of soft wood may be placed as shown in the detail, the strip being held by Z-bar lugs 4 ins. long, 5 ft. apart. These lugs are secured by bolts through slotted holes which permit of adjusting the lug to the calking strip.

This piling is the invention of Mr. Henry Wittekind, an engineer in the office of Jennie & Mundie, architects, Chicago. It is manufactured by the H. Wittekind Interlocking Metal Piling Co., 218 La Salle St., Chicago.

MOTOR CARS FOR ROAD AND RAILWAY service are to be introduced by the Great Western Ry., of England. The road cars will serve as feeders to the railway in country districts, running between the stations and outlying towns and villages, in connection with the trains. Five of these motor cars have been built, and two are in use in Cornwall, running between Helston Station and Lizard Point. The railway motor cars will provide an auxiliary local service between country stations, the cars stopping also at road crossings and at small villages having no regular stations. The first service will be between Stonehouse and Chalford, seven miles. There are now two intermediate stations, but the steam cars will stop at four additional points. This class of service is being instituted partly to offset the competition by electric lines, especially in the short-distance journeys. The cars, which are now being built, will be propelled by steam power and will accommodate 52 passengers.

THE VIAUR VIADUCT ON THE RAILWAY LINE FROM CARMAUX TO RODEZ, FRANCE.

By M. René Bonnin.*

The French railway line from Carmaux to Rodez, which was opened for traffic on Dec. 18, 1902, crosses the high plateau of the Rouergue, whose altitude is about 500 m. (1,650 ft.) above the level of the sea. Great difficulties were encountered both in the preliminary studies and in the construction of the line. Different projects were considered with a view of finding a combination of grades and curves suited to the working needs of the line. After long and laborious studies the Higher Administration adopted the present roadway, which crosses the torrent of the Viaur, near the mill of Gô, at a height of 116 m. (380.57 ft.) above the bottom of the stream.

*61 Rue Louis Blanc, Paris, France.

COMPETITIVE PLANS.

The Administration of the Ponts et Chaussées, which had charge of the construction of the line, decided in 1887 to open a competition for plans for the construction of the viaduct, which was to cross the valley of the Viaur. French constructors who had already proved their ability in the building of important works of art were called on to present projects. A set of specifications was prepared. This, in order to admit of comparisons between the projects, stated that the viaduct should be of metal; it also gave the distance between the extreme points of the structure. The competitors were left entirely free in the matter of the number and position of the intermediate supports.

The metallic deck could be made of straight girders, either continuous or discontinuous, resting on metal or masonry piers, or on metal piers supported by a central arch, also of metal. Cantilevers were also allowed. The upper chords of the trusses of the bridge were to be high enough above the level of the rails to act as a parapet, in case of a train leaving the track, and the floor was to be made sufficiently strong not to give way under the shock of a derailed locomotive. Either iron or steel could be used.

The calculations for strength were to conform to the circular of July 9, 1877, the only one then in force. The wind pressure was to be taken at 275 kg. per sq. in. (56.32 lbs. per sq. ft.) in case that the deck were not loaded, and at 150 kg. per sq. m. (30.72 lbs. per sq. ft.) in the contrary case.* The working load of the iron was to be that allowed by the circular of 1877, viz., 6 kg. per sq. mm. (8,534 lbs. per sq. in.), reduced to 5 kg. per sq. mm. (7,111.67 lbs. per sq. in.) for riveted work. In steel 10 kg. (14,223 lbs.) was allowed for the main arches and stringers; and 8 kg. (11,379 lbs. for riveted work.

The work was to be provided with the necessary apparatus for visiting all its parts. In addition to the general and detailed plans of the work, competitors had to give the strains on all the different parts of the viaduct, and to explain in detail the methods proposed for erecting the structures. Last of all, they had to give a detailed estimate of the cost.

Seven projects were submitted to the Minister of Public Works. They were as follows:

Two by the Maison Eiffel (straight continuous girders on metallic or masonry piers).

One by the Société des Ponts et Travaux en fer (straight continuous girders on metallic piers).

Two by the Maison Darydé et Pillé (the first with straight continuous girders on metallic piers; the second with lattice girders formed by two double brackets meeting at the center to form one continuous girder of three spans). The middle span to be 170 m. (557.74 ft.) long, and the side spans 100 m. (328 ft.). The girder to be supported by metallic piers.

One by Mr. Seyrig, formed of a center arch of 219 m. (689 ft.) span and 52 m. (170.60 ft.) rise, of simple lattice work, with ends fixed at the springing lines, and with nine spans securely connected by means of horizontal diagonal ties. The chords were I-shaped and rested on metallic piers and on the arch. It was an arrangement similar to that of the bridge over the Douro.

One by the Société de Construction des Batignolles, of a type wholly different from those of the other competitors. Its principle was that of balanced, or courterpoised arches. The work was composed of a central simple trellis arch, with U-shaped chords, pivoted at the top and at the springing lines. The halves of the central arch were counterpoised by two cantilevers securely fastened thereto. Two connecting spans bore on the end abutments and the extremities of the cantilevers. The central span (Fig. 1) had a span of 250 m. (820.20 ft.) with a rise of 45.37 m. (148.84 ft.), a ratio of $\frac{1}{5.51}$. The end spans were 54.60 m. (179.13 ft.) long, and were connected to the masonry abutments at the ends by a metallic junction beam 25.40 m. (84.33 ft.) long. The height of the rails above the bottom of the valley was 115.80 m. (379.91 ft.). The total cost was estimated at 1,861,000 francs ($358,000).

*These wind pressures were the extremes to be considered. The arc of 275 kilos. per m.² was the maximum to be considered under any circumstances. When the pressure reached 150 kilos. per m.² trains were not to be allowed to cross the bridge, and, *a fortiori*, when this last pressure should be exceeded. These pressures were modified, as will be seen further on, by a subsequent circular.

In view of the advantages offered by this plan over the other projects submitted, both from the technical and economical standpoints, the Minister of Public Works, acting under the advice of the engineers in charge of the work, and of the Commission which had the competition in hand, adopted by a decision of Aug. 30, 1889, the project presented by the Société des Batignolles, which had been worked out by M. E. Godfernaux, Chief Engineer of the Metallic Construction Service, with the assistance of M. Bodin, engineer of the same service, and invited the Société to submit its finished and detailed project.

PRINCIPLES AND ADVANTAGES OF BALANCED ARCHES.

It is known that, when a metallic arch bridge is to be built, the arch is generally made with three articulations, one at the summit and one at each of the springing lines. The object of these articulations is: (1) To make the stresses acting on these arches calculable by the rules of statics; (2) to reduce the height of the arches to a minimum; (3) to reduce to zero the strains resulting from changes of temperature (Fig. 2).

None the less, when the span is large, and especially when it reaches the proportions of that of the Viaduc du Viaur, great stresses are brought to bear on the arch by reason of the action of the dead and live loads, involving a great increase in the section of the arches and, as a consequence of this, a large additional amount of metal. The resulting thrusts require very voluminous, and therefore expensive, abutments.

There is a simple way of overcoming this difficulty and of reducing the thrust. It is enough to balance the central span by building on to it, and on the other side of the pier or abutment, a counterpoise for half the span, which remains articulated at the summit, in the shape of a semi-arch of metal which is made a solid whole with the first. This counterpoise is called the cantilever. The arrangement in Fig. 3 is thus obtained:

Let it be supposed that the dead and live loads are laid in the bridge symmetrically with regard to the articulation at the summit A, the ends B and C being supposed to be free. It will be easy to determine the bending moments due to the dead and live loads in the two half-arches E A D and E B D, which are taken to be imbedded along the plane E D. These bending moments are represented by the curve a b c (Fig. 4) for the half-arch E A D, and by the curve d e f for the cantilever E B D. The length g f will give, for the plane E D, the bending moment due to the cantilever, while the length g c represents, for this same plane, the bending moment of the half-central span. The resultant thrust, which is horizontal in this special case, will be represented by:

$$Q = \frac{1}{b}(g\,c - g\,f), \qquad (1)$$

in which b is the rise of the arch.

The resultant bending moments will be, for the half-center span, call X the bending moments already found:

$$Xt = X + \frac{z}{b} Q,$$

in which z is the distance from the neutral axis of the arch to the horizontal line passing through the articulation at the crown.

For the cantilever B D, the bending moments will not be changed and will be equal to those of X′ already found:

$$X't = X'.$$

Hence it will be easy with these data, either by means of graphical statics, or by relying on the

known rules of the strength of materials, to calculate the different sections to be given to the chords of the half-center arch, and of the cantilever, as well as those to be given to the panels which form the spandrels of the arches.

In case that the live loads should not be distributed symmetrically in regard to the articulation A (Fig. 5), each of the half trusses A B and A C would have to be considered separately. The

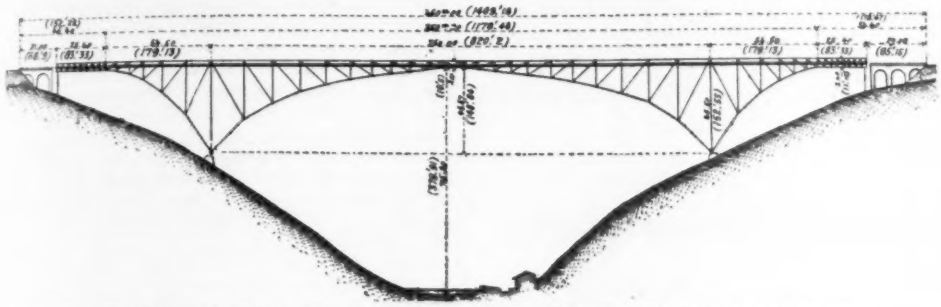


FIG. 1. PRELIMINARY PLAN FOR VIAUR VIADUCT SUBMITTED BY THE SOCIETE DE CONSTRUCTION DES BATIGNOLLES.

mutual reaction of these two trusses will no longer be horizontal, but be decomposed into two stresses, one horizontal Q which will be the thrust, and the other vertical P'. The ends of the cantilevers being free, it is easy to calculate, for each truss, the sum of the moemnts of the live load, which comes directly upon it, with respect to the points of support D and G. These two equations of equilibrium will be established; calling M_d and M_g the moments about D and G, respectively:

$$\text{Truss A B: } Q\,b - P'\,a + \Sigma\, M_d\, P = 0,$$
$$\text{Truss A C: } Q\,b - P'\,a + \Sigma\, M_g\, P = 0,$$

and these equations will give the means of determining the values of Q and P' applicable to the case of live load considered. Knowing in this way all the forces which act on each of the trusses, there will be no difficulty in determining the resultant bending moment for each of their sections, therefore, in knowing the sections to be given to the chords of the trusses and to the panels of the spandrels.

If a glance be cast back at formula (1), which gives the value of the thrust, it will be seen that this thrust is a function of the three variables b, g c and g f. It is inversely proportional to b; that is, to the rise. Hence the greater the rise the less will be the thrust, which was already evident. But, on the other hand, so long as g c, the bending moment at the plane of junction E D, due to the center half-span, is greater than g f, the bending moment due to the cantilever, just so long will the value of Q be positive, and the result of the thrust will be a tendency to open the center span D G. The resultant of the pressures on the abutments D and G will be inclined to the vertical, and the spring of the arches, as well as the masonry of the abutments, will have to have the same inclination.

If, by any change of the live load or the dead load, g c become equal to g f, Q becomes equal to 0, and the thrust disappears. The reaction at the abutment becomes reduced to a vertical pressure and the end B of the cantilever being free, any change in the live load would involve a state of unstable equilibrium. Finally, if g f became greater than g c, the thrust Q would become negative and tend to bring together the two points of support D and G.

Setting aside the last two cases mentioned, and considering only the first, that is, the one in which the thrust is positive, and tends to separate the two supports D and G, it is seen that it is possible, either by changing the length or the weight of the cantilever, to reduce, for a given width of span for the center arch, the difference g c — g f of the bending moments in the junction plane D E, to limits suited to obtain the thrust which it is considered well to adopt. This thrust should always be positive, whatever be the position of the live load, without exceeding, however, a certain limit, in order to insure the working of the center articulation in all cases.

When, on the contrary, the total length B C of the viaduct is fixed, it is possible to determine the dimensions of the rise b, of the span 2a of the central arch and of the length a' of the cantilever, so that the thrust Q shall be positive and contained within the desired limits.

When, for any exceptional reason, the spans are fixed in advance, as the rise of the center arch and the reduction of the thrust of the latter do not seem to be sufficient, a still further reduction of this thrust can be obtained by reducing the rise of the cantilever which forms the end span. The arrangement shown in Fig. 6 is obtained in this way. The negative thrust of the end span is thus increased.

If, as in the preceding case, the bending moments, due to a dead and a live load symmetrically arranged with regard to the articulation A, be calculated for the half-center span and for the cantilever, the curves of Fig. 7 will be obtained. As the rise of the center arch is b, the thrust due to this span, supposed to be isolated, will be:

$$Q = \frac{1}{b}\, g\, c.$$

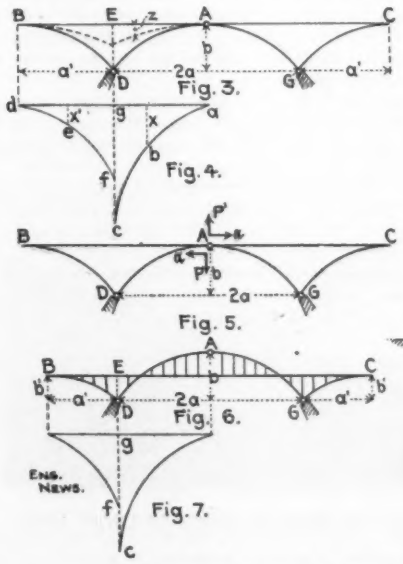
For the cantilever, which forms the end span and has a rise b', the negative thrust due to this bay will be,

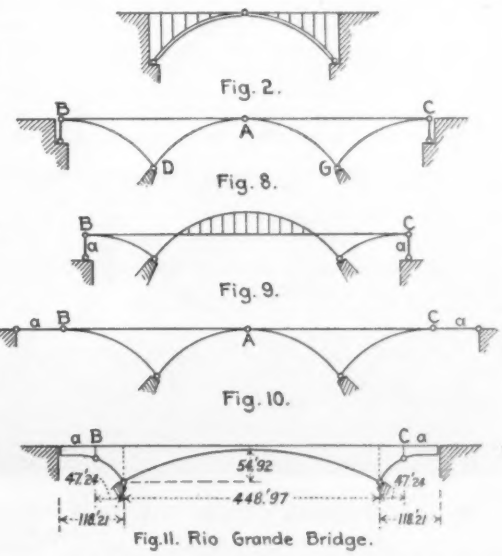
$$Q' = \frac{1}{b'}\, g\, f.$$

Hence, the resultant thrust will be,

$$Q - Q' = \frac{1}{b}\, g\, c - \frac{1}{b'}\, g\, f.$$

From this equation can be obtained the rise b'





FIGS. 2-11. DIAGRAMS ILLUSTRATING DISCUSSION OF BALANCED ARCHES.

of the cantilever necessary to give the resultant thrust Q — Q' desired:

$$b' = \frac{g\, f \times b}{g\, c - b\,(Q - Q')}.$$

An example of this arrangement will be given further on.

The great advantage of this arrangement of balanced arches having an articulation at the crown of the central span is that the combination is uninfluenced by changes of temperature. There is from this cause no variation in the stresses brought to bear on the bars of the metallic trusses; the geometrical shape of the arch alone is changed.

It has been assumed so far that the ends B and C of the cantilevers, which form the junction between the metallic parts of the bridge and the end abutments, were perfectly free to move either vertically or horizontally. A serious trouble arises from this freedom of vertical movement. Whenever live loads pass over the bridge, or whenever changes of temperature occur, there is caused at the crown of the arch and at the end of the cantilever, an up-and-down motion of the floor, and consequently of the roadway. The consequence of this vertical movement at the end of the cantilever is a difference of level between the level of the rails on the abutment, which stand fast, and that of the rails on the bridge which are movable, and this difference of level becomes the cause of shocks which cannot be allowed in practice.

The vertical movement at the end of the cantilever can be prevented by tying the latter down firmly to the masonry of the abutment. According to the circumstances of the case, the anchoring pieces will be subjected to forces of extension or compression. This is the system adopted for the Mirabeau bridge, built on the system of balanced arches. The arrangement is shown by Fig. 8.

The rules of statics, indicated for use when the ends of the cantilevers, B and C, are free, are now no longer sufficient. Recourse must be had to the formulas for elasticity, and the calculations become much more complicated. Such an arrangement was adopted for the construction of the foot-bridge across the Seine, between the Alma and Iéna bridges, at the time of the Exposition of 1900. The ends B and C of the cantilevers (Fig. 9) were fastened to the masonry by a tie-rod a, which kept this end vertically firm. Moreover, in order to increase the negative thrust of the end spans, whose dimensions were limited, the arrangement noted a little way back, of reducing their rise, was adopted. The stringer B C, which ties the whole together and carries the floor, cuts in this case the central arch from which, for a certain distance, it is suspended by means of vertical members. But here the articulation at the crown has been suppressed, which complicate still further the calculation of the shams on the arches.

In order to avoid this complication and, especially, to do away with all indetermination in the calculation of the strains bearing on all the many pieces of the viaduct, it was thought necessary, in so important a work as the Viaur Viaduct, to abandon this connection of the metallic part of the bridge with the masonry of the abutment, while still retaining the articulation at the crown of the center span. Fig. 10 shows the arrange-

ment adopted. The end of the cantilever B, which is entirely free, is joined to the abutment by a metallic junction beam a. The slight changes in slope of this beam make up for the vertical movements of the end of the cantilever.

A bridge having nearly the same arrangements has just been built in the republic of Porto Rica,* on the railway line which, passing through the city of San José, connects the Carribean Sea with the Pacific Ocean. This bridge crosses the river Rio Grande, which, at this point, flows at the bottom of a very deep ravine (Fig. 11). The dimensions of this bridge are very much less than those of the Viaduc du Viaur; the central arch has a span of but 136.85 m. (448.97 ft.) and a rise of 16.74 m. (56.10 ft.). As in the Viaduc du Viaur, the ends B and C of the cantilevers are connected to the masonry abutments by metallic junction beams a. But the articulation at the crown of the center arch has been suppressed, hence the calculation of the strains could only be made with the help of the formulas of elasticity. The very small ratio of the rise of the center arch of this bridge to its span, $\frac{16.74}{136.85} = \frac{1}{8.175}$, and the still smaller ratio of the length of the cantilever to the span of the center arch $\frac{14.40}{136.85} = 0.105$, should be noted. Such unfavorable proportions, which surely must have been made necessary by local conditions, could only have reduced slightly the thrust of the center arch, which, by reason of the small rise, is itself great. The resultant maximum in the most unfavorable case given by the published figures, reaches the amount of 488 tons per truss, a figure which appears high in view of the relatively small span. An increase in the rise and greater length of the cantilever with regard to the span of the center arch, would have reduced, undoubtedly, this thrust, and lessened the weight of the metallic portion.

As the Viaur Viaduct is built, the ratio of the span to the rise is $\frac{53.73}{220} = \frac{1}{4.1}$, and the ratio of the length of the cantilever to span is $\frac{69.60}{220}$ = 3.16. The maximum thrust, as will be seen further on, under the most unfavorable case of live load, is only 421 tons per truss; that is, less than the 488 tons of the Rio Grande bridge, whose span is far smaller.

The arrangements which have just been mentioned as adopted for the Viaur Viaduct, made it possible to calculate, by the laws of statics alone, the sizes of all the members of the bridge, and to see clearly and without any doubt the strains they have to bear.

It was by starting from these principles that MM. Godfernaux and Bodin studied the project submitted at the competition by the Société des Batignolles, a project which has been carried into effect after the making of a few changes which will be mentioned. It will be added that the Société de Construction des Batignolles has patented the new arrangement applied to the Viaur Viaduct.

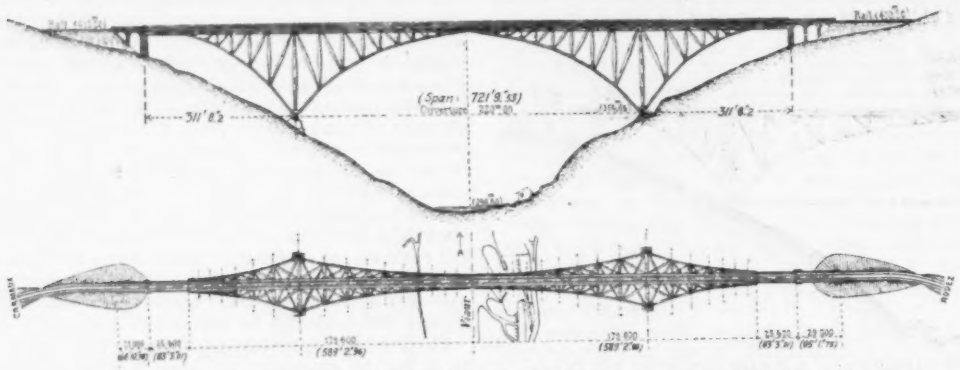


FIG. 12. FINAL PLAN AND ELEVATION OF VIAUR VIADUCT.

FIG. 12 A. GENERAL VIEW OF THE VIAUR VIADUCT, CHARMAUX RODEZ RAILWAY LINE, FRANCE.

CHANGES MADE IN THE COMPETITIVE PROJECT; FINAL PROJECT.

As a result of the decision of August 30, 1889, the Société des Batignolles began the study of the final project for the Viaduc du Viaur. But before taking this study up, a few secondary questions had to be settled with the Higher Administration, especially in regard to the arrangement of the railing, which was to be built throughout the length of the viaduct as a protection against derailment, and in regard to the means for visiting and keeping up the metallic parts, as these means had only received a slight consideration in the preliminary project. A little while after the settlement of these questions, the new regulations of Aug. 29, 1891, appeared. These new regulations laid down, for metallic works, entirely different conditions from those contained in the regulations of 1877, which had served as the basis for the preliminary project.

The live loads to be assumed (rolling loads and wind pressures) were no longer the same, and the working strength of the metal was entirely changed. The working coefficient for the steel of the main trusses was to be determined by the formula:

$$R = 8 + 4\frac{A}{B}, \text{ in which}$$

A = smallest strain to be borne,
B = largest strain to be borne,
given by the new regulations.

The final project was prepared therefore on these new bases, retaining, however, the same general arrangements as in the competitive project with a center arch of 250.00 m. (820.21 ft.) span. The total cost was increased to 3,000,000 francs = $577,000. This project when submitted gave rise to various remarks. The thrusts at the crown were:

In the most unfavorable case	906.7 tons
In the average case (permanent load)	640.0 "
In the most favorable case	567.6 "

These thrusts seemed high and gave rise to apprehension lest the articulation at the crown would not work satisfactorily. Moreover, these heavy thrusts would certainly cause great strains in certain posts and struts as well as in the chords, and thus involve sections which there would be certain practical difficulties in realizing. The curve of the lower chords of the center and side spans was not, in either case, wholly pleasing to the eye. The project, from the economical standpoint, showed a marked increase of cost over the competitive project. In a word, the center arch did not seem sufficiently counterbalanced by the side spans.

Hence, the most natural thing to do seemed to be to change the proportion of the work by: (1) Making the cantilevers more important; (2) reducing the center span in proportion to the cantilevers. The result of these changes was to reduce the thrust. The curves of the lower chords of the arches were less strained. Moreover, as the panels were higher, the forces acting on the chords

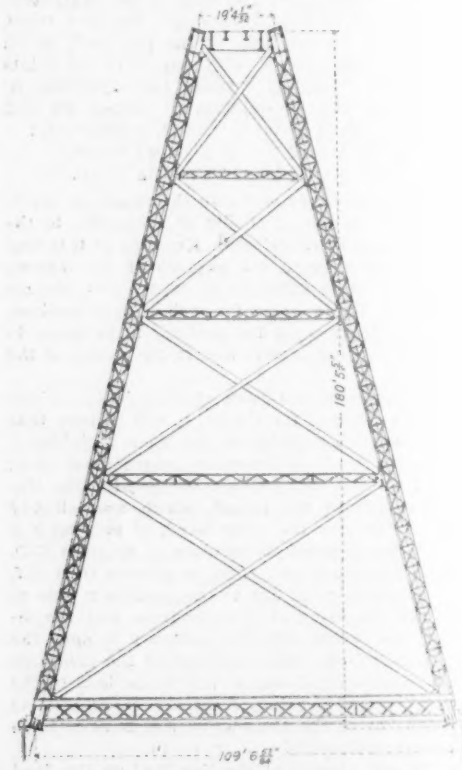


Fig. 16. Section of Main Span at Post 40, Showing Batter of Ribs.

were lessened. The general appearance of the work was improved. Finally, the total cost would be greatly cut down.

The changes made in original project for the Viaduc du Viaur are similar to those mentioned above, in speaking of the Rio Grande bridge. In view of these unquestionable advantages, the study of the final project was continued with these new data:

Length of central span	220.00 m.	(721.78 ft.)
" of cantilevers	69.60 "	(228.35 ")
" of connecting span	25.40 "	(83.33 ")
Total length	410.00 "	(1,345.14 ")
Rise	53.731"	(176.282")
Estimated cost	2,452,105 frs.	($472,000)

In spite of this reduction of 30 m. (98.44 ft.) in its width, the central span of the Viaduc du Viaur is the largest opening used for any arched metallice railway bridge, built up to the present time, either in France or abroad. The span of the arch of the Garabit Viaduct is 165 m. (541.33 ft.); that of the Mungstein Viaduct, in Germany, is 169 m. (524.93 ft.) clear span; and that of the Niagara

*See Engineering News, Oct. 23, 1902; p. 326.

*These figures would be in American tons of 2,000 lbs.: 597.37, 704, and 624.36 tons, respectively.

bridge, which replaced Roebling's suspension bridge built in 1855, is 168 m. (551.18 ft.). The span of the Viaur Viaduct is exceeded only by that of the Clifton arch bridge, also across the Niagara, which is 256.10 m. (840.24 ft.); but this last is only a highway bridge which carries a single track tramway line.

The principal features of this final project, approved by a ministerial decision of April 8, 1896, will now be described:

DESCRIPTION OF THE WORK.

The main lines of the bridge are given in plan and elevation by the general drawing (Figs. 12 and 12A). It is composed of a central arch-shaped span 220 m. (721.78 ft.) long, with two end spans

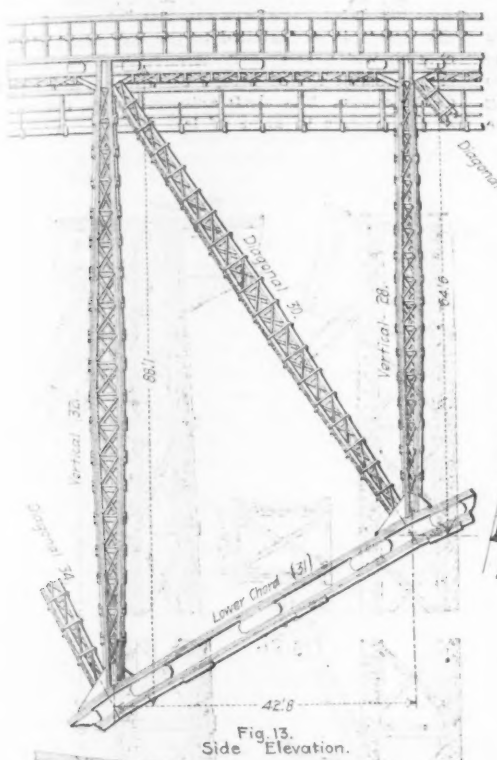


Fig. 13.
Side Elevation.

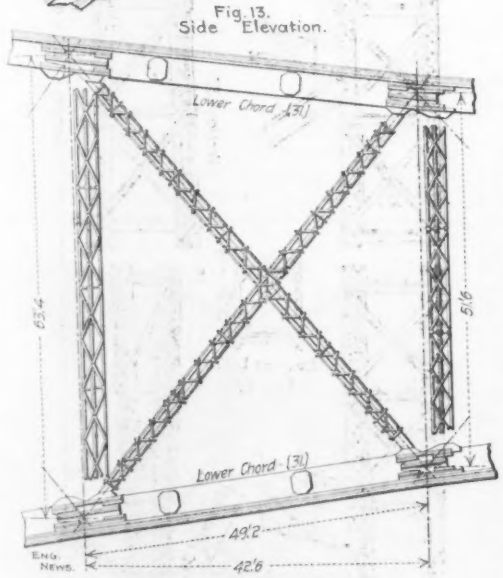


Fig. 15. Plan of Transverse Bracing in Plane of Lower Chord.

made up partly of bracket-shaped half-arches, built on to the center bay, and partly by a junction span, of which one end rests on the bracket and the other on the masonry abutment. The length of each end span is 95 m. (311.68 ft.), of which 25.40 m. (83.33 ft.) is taken up by the connecting member. The clear length between abutments is 410 m. (1,345.14 ft.), and the total length including the abutments is 460 m. (1,509.18 ft.). The height of the rail above low water is 111 m. (364.17 ft.).

The metallic part comprises two trusses which support the track on top (Figs. 13, 14, 15), and rest on their lower end on low masonry supports built solidly into the rock. Each of the two trusses is divided into two equal parts by an articulation at the crown. Other articulations to receive the metallic arches are built on the masonry supports. The rise of the middle arch is 53.73 m. (176.28 ft.). The trusses lean toward each other, each at the rate of 25% to the vertical, so that the c. to c. distance, which is 5.89 m. (19.32 ft.) on top, becomes 33.39 m. (109.55 ft.) at the articulations of the springing lines (Fig. 16).

As already said, the reasons for these arrangements are: The prolongation of the arches into the bracket-shaped end spans diminishes the thrust of the center arch, a thrust which would be much too great without this counterweight. The

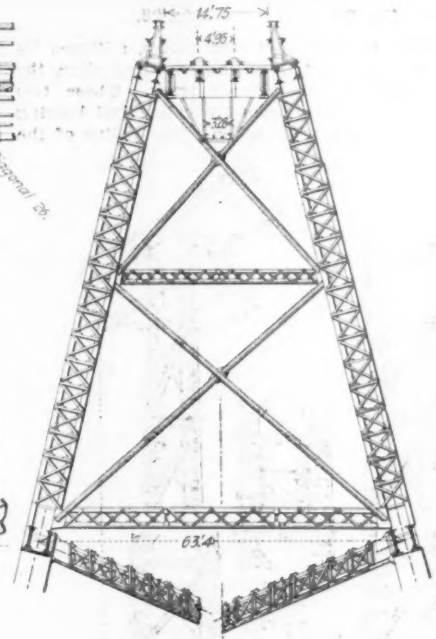


Fig. 14. Cross Section Looking towards Abutment.

FIGS. 13-15. DETAILS OF MAIN ARCH CONSTRUCTION AT PANELS 28 TO 32.

width of span of the middle arch can be reduced by throwing a part of it to the outside of the point of support. The connecting spans leave the cantilevers independent of the masonry of the abutments, making them free to move under the action of live loads, wind pressure or changes of temperature. The articulations fix the points through which the strains developed in the structure must pass; they make keying up relatively easy, and prevent appearing at the crown abnormal strains which are very hard to determine when the articulation does not exist; they also make the arch insensible to changes of temperature. The arch can be set up safely without false-works, because during construction it works in a way which can be calculated beforehand.

Each half-truss is composed of a straight upper chord and a polygonal lower chord, connected by posts and braces which form the spandrels of the arch. The intersections of the polygonal sides of the lower chord correspond to the positions of the posts. The axes of the braces pass through the intersections of the posts and chords, these intersections being called the panel points. The trusses are divided into triangles, without unnecessary bars.

The posts which are opposite each other in the two trusses, as well as the chords to which they are attached, are connected together by vertical and horizontal cross-braces, so that in the portions near the springing lines there are several of these crosses superposed; while in the parts near the crown a single cross is sufficient. The cross-bracing in the plane of the lower chords connects this part of the trusses. The upper chords are connected in like manner by a horizontal bracing placed on the stringers. Further connections are formed by the deck girders which carry the track (Figs. 17, 18 and 19).

The masonry supports or piers are formed of four independent masses, by reason of the great distance between the feet of the trusses. These masses are of rubble masonry, capped by three courses of hard cut stone connected together by iron cramps. They contain the iron bed plates, set in the masonry, to which access is had by galleries. These bed plates serve as a support for the anchoring rods which fasten the metallic framework of the bridge very solidly to the abutments so as to increase the stability of the whole against the wind.

The trusses and the pieces which connect them together are made of mild laminated steel. The guard rail is made of the same material. The connecting spans, the deck girders, ladders and apparatus for visiting and maintaining the different parts of the bridge are of laminated steel.

TRUSSES.—The chords (Fig. 20) are U-shaped with vertical sides. According to the strains to be borne, the flanges and webs are made of one or more thicknesses superposed, and connected by four angles of $\frac{100 \times 100}{12}$ (nearly $4 \times 4 \times \frac{1}{2}$ ins.), and bordered by four other angles of the same size. The joints are formed by double cover-plates. At the panel points the sheet metal is replaced by large gussets, the dimensions of which allow the members forming the spandrels to be securely fastened.

Frames of flat and angle irons, placed crossways to the length of the chords, and riveted to the webs and flanges, and a lattice work riveted to the angles at the edges, assure the shape of the chords. In some of the harder-worked parts of the chords this lattice work is replaced by one or more pieces of solid sheet metal.

The posts and braces are made in two ways, according to their position in the bridge. The largest braces, which support the heaviest loads, are tubular in shape; the shorter ones are I-shaped. The braces are formed of four angles, arranged as shown in Fig. 21, connected on the four sides by lattice work, and stiffened when necessary by flat irons. The preservation of their shape is had by frames (Fig. 22), placed normal to their axes, and between the frames by the crossing of the cross angles which form part of the lattice of the faces and make up the posts. The width of the bars parallel to the axis of the bridge increases from the panel points to the middle, so as to make

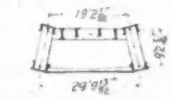


Fig. 17.
Section at Post No. 68.

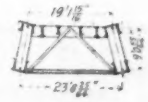


Fig. 18.
Section at Post No. 0.

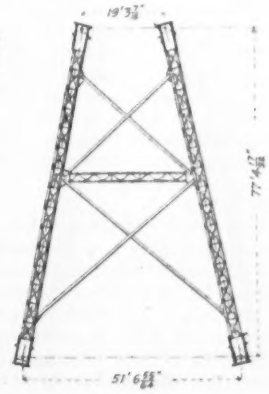


Fig. 19
Section at Diagonal No. 30.

Figs. 17-19. Transverse Sections of Arch, Showing Bracing Between Ribs.

them somewhat enlarged at the center, as shown in the posts (Figs. 23 to 27).

These last are also made of four angles (Fig. 28), stiffened or not by plates laid along their length, but fastened to the outside of the chords so as not to interfere with the braces which are fastened to the inside of the webs. This arrangement facilitates the attachment of the posts and braces to the webs of the chords. The posts, like the braces, are enlarged at the middle or the sides parallel to the axis of the bridge. The lattice work placed on the four faces insures, as in the

braces, the preservation of the form of the posts which work generally in compression.

Where fastened to the webs of the chords the lattice work is replaced by solid flat metal, which forms rigid frames and solid braces between the

Fig. 20.

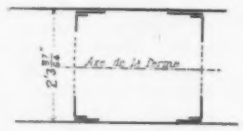
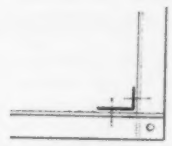


Fig. 21.



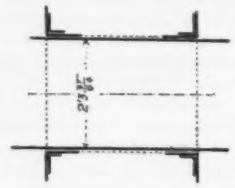


Fig. 22. Fig. 28.

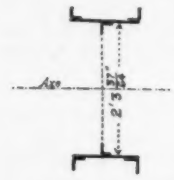


Fig. 33.

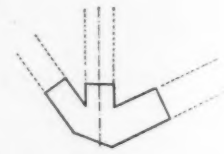


Fig. 34.

two sides, and helps to preserve the shape of the panel points (Figs. 29 to 32).

The I-shaped posts and braces (Fig. 33) are made of two channels, each composed of a web of sheet metal and two angles, placed back to back with a web of lattice work between. The section varies according to the strength required. The angles, and the plates forming the webs of the channels, are of different sizes according to the sections called for by the calculations. These pieces have all the same height of 0.800 (3.15 ins.).

At the foot of the truss (Fig. 34) where the lower sills and the main post come together, the sides are strengthened by several thicknesses of plates, and connected by means of flat connecting pieces, so as to give great strength to this part which carries the whole structure. It is cut obliquely by an inclined plane which rests on the corresponding part of the upper hinge plates. Strong forged steel squares are riveted to the above inclined plane over a surface of sufficient size to distribute the pressures properly. A similar arrangement of pieces is made at the crown in order to receive the pieces which form this articulation.

CROSS AND DIAGONAL BRACING.—The two trusses placed opposite each other are connected in the following way:

(a) At the panel points of the lower chords, by horizontal straight members whose shape depends upon their position in the structure. Those which correspond to tubular posts are tubular; those to I-shaped posts are I-shaped. Diagonal cross-braces are placed, in the plane of the chord, between the straight members just mentioned; their shape conforms to that of the members between which they are set (Figs. 14 and 15).

(b) At the level of the upper chord, by the deck girders of very strong plate and angle irons, having double solid sides at the tubular posts and single sides at the I-posts (Figs. 13 and 14).

(c) Between the horizontal straight members, as mentioned above, by cross-bracing, in several stories when the height of the trusses requires it, with horizontals between each story, fastened by plate gussets to each post, these gussets also fastening the arms of the crosses (Figs. 14, 16 and 19).

Invariability of shape is had for the tubular horizontal members and diagonal bracing as it is in the posts and braces of the spandrels, by means of frames let in at given distances. The horizontal at the foot of the truss is under heavy strain; its construction gives it great resisting strength. It is formed of two I-beams placed vertically one above the other and connected by means of a lattice, the latter having a height of 2.30 m. (7.55 ft.)

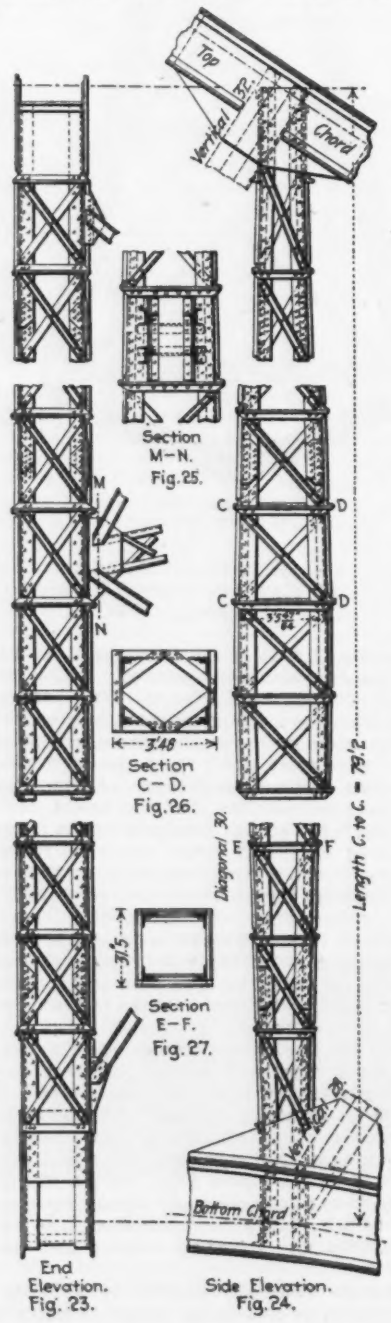
TRACK.—The track (Fig. 14) is supported by: (1) The deck girders already mentioned; (2) the I-shaped main stringers which are placed between the deck girders and near the edge of the upper chord; (3) the I-shaped secondary girders, set between and fastened to the main stringers; (4) the secondary stringers, also I-shaped, between the secondary girders.

The tops of the stringers are all in the same plane and carry the decking. This is made of zores irons laid almost in contact, normal to the axis of the track. Several courses of plates are fastened to the zores irons and bind them together. The track rests on two of these plates, to which it is secured by bolts and stirrups.

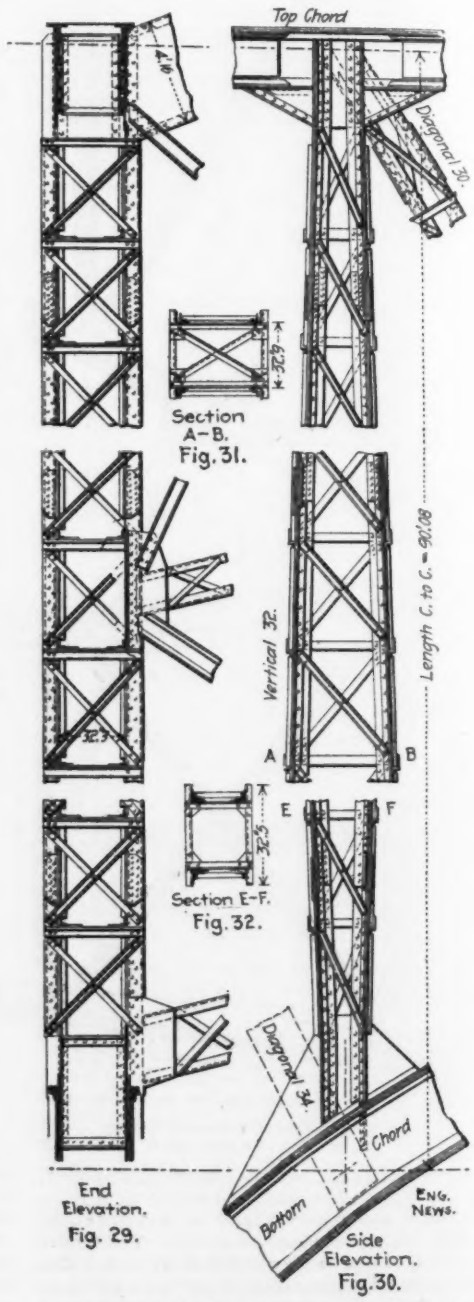
SKEWBACK PEDESTALS.—The supports on the piers (Fig. 35) are formed by: (1) A lower cast-iron plate in two thicknesses, with grooves to receive the adjusting wedges, thus giving the means of changing slightly the position of the articulations according to the necessities of construction. (2) Two cast-steel plates, stiffened by ribs, the lower resting on the cast-iron plate, the other carrying the metallic truss. These two plates are in contact along a cylindrical bearing which forms the articulation. The radius of the bearing is 0.30 m. (11.81 ins.). The concave face is in the lower plate, the convex in the upper.

The upper face of the masonry is inclined so as to be normal to the mean direction of the reactions at the pier. A part of the face is left horizontal so as to prevent any slipping during construction.

CENTER HINGE.—The articulation at the crown (Fig. 36) is formed of a steel circular shaft, 0.30 m. (11.81 ins.) in diameter, rolling on two cast-steel plates fastened to the last panel of the chords, which is greatly strengthened so that it can transmit to the bridge the thrusts developed at the crown. The shaft extends beyond the webs of the trusses in arms of less diameter, each of which engages in two connections fastened to the ends of the trusses. These arms and connections are a precautionary measure in case the articulation at the crown should show any tendency to open.



Figs. 23-27. Details of Diagonal Brace 30.



Figs. 29-32. Details of Vertical Post 32.

CONNECTING SPANS.—These parts of the structure are of no special interest. The girders of this span end on the cantilever side in a beveled extremity, which rests on the last horizontal of the cantilever by means of supporting plates so arranged as to allow a slight displacement

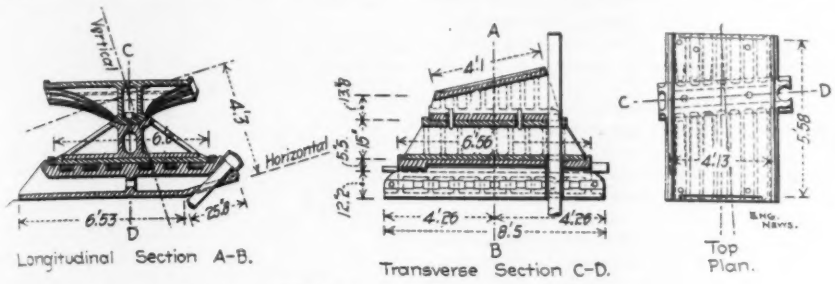


FIG. 35. DETAILS OF SKEW BACK CASTING.

about a horizontal axis. At the abutment they bear on a plate furnished with expansion rollers.

ACCESSORY PARTS.—A very strong railing (Figs. 13 and 14), 1.80 m. (5.90 ft.) high, runs along the entire length of the viaduct. It is intended to hold back a train in case of derailment. It is made of solid plates very strongly braced against the top chord of the bridge.

A foot-bridge (Figs. 13 and 14), in the axis of the bridge, runs under the deck girders throughout the entire length of the structure. Millers' ladders are placed on the lower chord, and ordinary ladders are attached to most of the posts and braces. These ladders communicate with the longitudinal foot-bridge by small cross-bridges

The abutments, formed of masonry arches, offer no special interest.

METHODS OF CALCULATION.—The calculations were all made by statics alone, each half-truss being assumed in equilibrio under the action of the dead load, live loads, wind pressures, and reactions devoloped at the articulations. The dead load was determined by several successive calculations. It was applied partly at the upper panel points and partly at the lower panel points of the truss. The live load was that of the test train described by the circular of August 29, 1891, composed of two locomotives (each having four axles), 8.80 m. (28.87 ft.) long, and weighing 56 tons (61.6 American tons), each accompanied by a tender 6.50 m. (21.65 ft.) long, and weighing 24 tons (26.4 A. T.), followed by —— cars* 6 m. (19.68 ft.) long and weighing 16 tons (17.6 A. T.). This train was placed in the most unfavorable position for each member of the trusses. The stresses were determined according to Ritter's method, by taking sections in the structure which, including only three members, allowed the stress

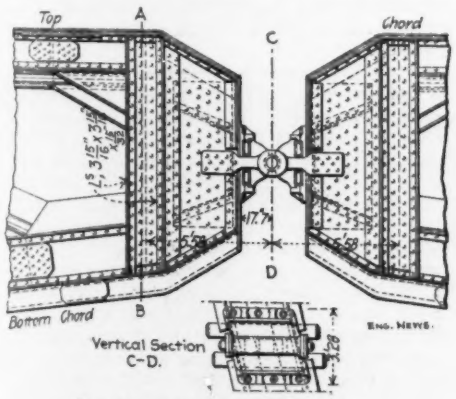


Fig. 36. Details of Center Hinge.

on each of them to be found by taking the moments about the point of intersection of the other two, the system being supposed to be articulated at the panel points.

The wind pressure was estimated, in conformity with the instructions of the circular, at 270 kg. per m². (55.30 lbs. per ft.²) when there is no train on the bridge, and at 170 kg. (34.80 lbs.) when there is one.

*The number of cars is not stated in the circular. It is generally as many as the bridge will carry.

The extreme working limits allowed for the steel members of the trusses were 11.50 kg. per sq. mm. (16,357 lbs. per sq. in.) for the neat section, with a large reduction for members under compression, or for those exposed alternately to compression and extension. For members working always in the one way the circular gives, as an indication of the working limit:

$$R = 8 + 4\frac{A}{B},$$

and for pieces working alternately under compression and extension,

$$R = 8 - 4\frac{C}{B}.$$

In these A is the least and B the greatest stress in the same sense, and C is the greatest in the opposite direction.

The work of the deck girders and stringers is limited to smaller stresses, or 7.50 kg. per mm.² (10,668 lbs. per in.²).

The sections were determined by dividing the stress by the work allowed, and for members under compression by applying Rankine's formula:

$$R' = \frac{R}{0.00008\left(\frac{l}{z}\right)^2},$$

in which l is the length of the piece, and z its radius of gyration.

Finally, the displacements which might take place in the bridge under the action of live loads or wind, were calculated carefully by the formula for the virtual work of a material system in equilibrio, and the probable displacements, either vertical or horizontal, appear to have kept within very small and wholly satisfactory limits.

METHOD OF ERECTION.

The parts of the metallic frame were assembled on a platform near the bridge, where they were reamed and riveted together in detached sections of a maximum weight of 4,000 kilograms (8,800 lbs.), except in the case of the lower chords where the weights were much greater. These last were assembled in a workyard at the right of the site of the bridge, then reamed and riveted. They were hoisted into place by means of tackles hitched to timbers prepared for the purpose.

The cantilevers were mounted on a large wooden scaffold, on the upper chords of which moved a traveling bridge supplied with two electric windlasses. The two cantilevers were set up successively with the same scaffold carried from one bank to the other. The opposite posts and braces of the two trusses were raised together, from the post at the springing line out to the end. Wooden piers served to support the part of the cantilever, already set up.

The center arch was erected by extension from the sides to the center, the two half-arches coming gradually together. In order to balance the suspended part of the middle span, the end of the cantilever was anchored to a mass of masonry by means of rods whose length could be changed so as to raise or lower suitably the ends of the two trusses.

There was used for the erection a large traveling car (Fig. 37), with overhanging timbers, securely fastened behind to the framework of the bridge, and carrying a derrick by means of which the pieces were raised either from the ground, or from a track laid on the viaduct. At the forward end of this car was suspended a sort of cage with several stories of floors, and stairways for the movement of workmen and transportation of light pieces. As the crown was neared, this car was replaced by a much lighter derrick.

(A brief account of the erection of this viaduct is given in "Revue Generale des Chemins de Fer" for January, 1903, and from this we take the following items: The shore spans were erected on falseworks built up from the sloping sides of the valley. To erect the center span use was made of a peculiar form of traveler, whose construction is indicated by the diagram, Fig. 2. This traveler consisted of two plate girders A, one over each rib of the arch, connected by transverse girders at a and b. On this platform was mounted a crane B and a carriage C, both traveling on the girder A as a track. The ends of the carriage overhung the platform and the arch ribs, and to each overhanging end was hung a framework D long enough to reach to the lower chord panel point c. Each framework consisted of the verticals d, d, and the cross-pieces e, e, etc., and was stiffened by X-bracing, not shown. The cross-pieces of the opposite frameworks were used to support stagings or working platforms extending transversely across the bridge from which the riveting of the connections was done.

The diagram, Fig. 2, shows the traveler in position for erecting the second bay of the main span, which the girders of the traveler platform overhang. The crane and the carriage both have movement along the traveler platform, so that they can command any portion of the viaduct underneath. To erect a succeeding bay the traveler platform was simply pushed along one bay and anchored down to the completed work at the rear end. The traveler is said to have worked successfully and to have much facilitated the erection of the center span.—Ed.)

By reason of the articulation of the crown and the exactness of the work, the junction of the two trusses opposite each other was easily made by the placing of the articulation shaft.

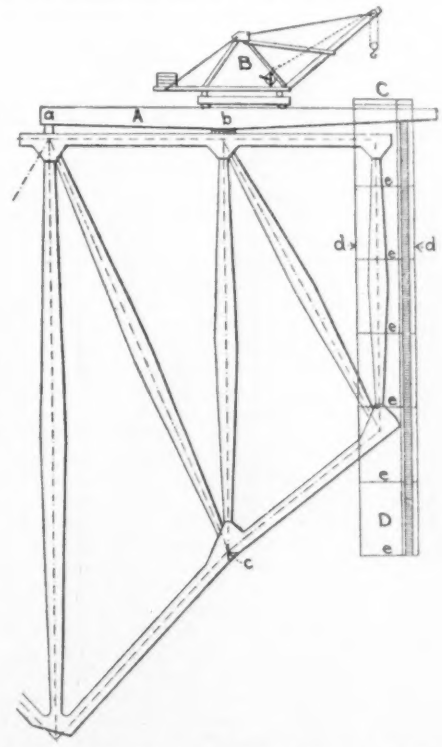


Fig. 37. Diagram of Traveler Used in Erecting Center Span of Viaur Viaduct.

As already stated, the work of the metal while erection was going on, could be exactly calculated in advance.

WEIGHT OF METAL IN THE FRAMES.

The total weight of the metal portions for a total length of 410 m. (1,345.14 ft.) is:

Steel.....	3,300	metric	tons	=	3,630	American	tons
Iron	380	"	"	=	418	"	"
Sundry metals..	220	"	"	=	242	"	"
	3,900	"	"	=	4,290	"	"

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Mr. Carnegie's presidential address at the Barrow meeting of the Iron and Steel Institute contains one statement which is sure to attract world-wide attention, viz.: a prophecy that the era of lowest prices for steel has gone, never to return. He says that "while hundreds of thousands of tons of 4-in. steel billets have been made and sold without loss for a penny, the limit has surely been reached here and it is doubtful if ever a lower price can be reached for steel." The reason which he assigns for this prophecy is the increasing scarcity of raw materials, a matter which is more and more engaging the attention of thoughtful men everywhere. The fact is that the human race as a whole remained in a comparatively primitive condition until about the dawn of the nineteenth century, and that it is only since that time and for the most part only in the latter half of that century that it has begun to make really serious inroads on the earth's stores of mineral products. It may be said that actual scarcity of iron ore is a thing of the distant future, and Mr. Carnegie specifically admits this. Nevertheless, the scarcity in other raw materials, such as lumber, for example, is bound to be reflected in increased operating costs in every industrial process. At the present time, however, the greatest factor in increased cost as compared with the "hardpan" era in the nineties is doubtless the increased cost of labor. In every other respect it is probable that the United States Steel Corporation is now mining, transporting and converting its ores into the finished product more efficiently and economically than eight years ago; but at every point the labor costs are higher, not only because of actual rise in wages but because of shorter hours and less efficient work.

While all the probabilities favor the correctness of Mr. Carnegie's prediction as to the lower limit of iron and steel prices, it need not be assumed that general scarcity and excessively high prices are to be expected. Steel at three pounds for a penny could only be made with the conjunction of cheap and abundant ore and coal of high grade and cheap and efficient labor. There are enormous stores of lower grade ores and fuels, which can be utilized in production whenever prices remain on a higher level long enough to induce capital to undertake the task of exploiting them.

As is briefly noted elsewhere in this issue, radical steps are being taken by the Parisian authorities to prevent a recurrence of the disaster which overtook a trainload of passengers on the Metropolitan underground railway on August 10. Some of the lessons taught by this accident were briefly commented on in our issue of August 20, and it will be seen from our note elsewhere that these lessons have apparently not been lost on those responsible for the future safe operation of the new Paris underground line. Of even more interest, however, is a communication which has been made public through the New York "Times" by Mr. George Westinghouse. This communication is in general a repetition of the warning given by the same high authority on the occasion of the Park Avenue tunnel accident in New York city (Eng. News, Jan. 23, 1902), but it goes a step further than that document and specifies some of the ways in which modern electric railway car and line construction needs to be improved to make the operation of such roads, particularly when carried on viaduct or through tunnel, as safe at least as if operated by other power than electricity. We quote from Mr. Westinghouse's letter as follows:

> The realization of the great cost of such an accident as the recent one in Paris, regardless of the horror of it, will undoubtedly cause the plans already decided upon to be most carefully reviewed, and should bring to the officials of the companies interested the highest skill in determining the requirements, the compliance with which will render the carrying of passengers on trains operated by electricity as safe at least as if propelled by other means.
>
> It seems almost axiomatic that the third rail should only be charged with electricity when required to operate a train; that there should never be more electric energy at any point of a third rail than sufficient to operate one train; that the electric machinery required upon a train should be reduced to a minimum, and should be so located as to be under the convenient supervision of the train attendants; and in all tunnel and elevated railroad work there should be no material to create fire or dense smoke.
>
> The following requirements, among others, can easily be complied with, and are respectfully suggested for consideration and discussion.
>
> 1. Trains to be constructed of iron or steel, with the interior finish of incombustible materials.
> 2. The division of the third rail for the supply of electric current into suitable sections, each section being supplied with current only when required to propel a train.
> 3. The limitation, by suitable devices, of the amount of current supplied to each section so that in the event of a short circuit on the train the current will be automatically and instantaneously cut off at a point some distance from such section of the third rail.
> 4. Provision for the cutting off of the current from each supply section of the third rail at the will of the motorman.
> 5. No other live conductors than the third rail to be in close proximity to the line.
> 6. No wires carrying high voltages except upon motor cars, and motor cars only at the ends of a train.
>
> The state of the electric art has so advanced that compliance with the foregoing requirements is simply a matter of additional expense, incomparable, however, to the financial losses which the companies will suffer if they do not make the electric operation of their railways absolutely safe.

This statement sets forth in no doubtful terms the duty devolving upon the engineers of electrical underground and elevated railways, and it cannot be lightly passed over by them if they wish to escape responsibility for such accidents as that which has recently horrified the people of Paris. We emphasize this because there has been a pronounced effort made by some of our electrical enginsering contemporaries to deride the idea that the Paris accident had any lesson to teach to electrical engineers, or was in any sense a reflection on the perfection of their present practice in the car equipment and line construction of electric railways. No faults of station and stairway construction and no degree of inadequacy in fire-fighting appliances or ventilating apparatus—and all of these desiderata appear to have been woefully neglected in building the Paris subway—can mitigate the fact that a decided improvement is desirable in the electrical engineering work of our underground and elevated railways. We say this with a full appreciation of the remarkable work which has been done by electrical engineers in developing the application of electrical power to railway transportation. With all this advance there is no disguising the fact that some of the old dangers of steam railway transportation have not been lessened and that some new ones peculiar to electric traction have been added. Mr. Westinghouse's letters on this and on the previous occasion to which we have referred, perform a commendable task in bringing attention to this condition and to the possible means of improving it.

The trial of the directors of the North Jersey Street Railway Co. for criminal negligence resulting in the fatal grade-crossing collision at Newark on Feb. 19 last, in which nine school children lost their lives, resulted, as might have been predicted, in the acquittal of the accused. The accident was caused by a heavily loaded electric car running on to the tracks in front of a Lackawanna train, its motorman being unable to stop his car in time on account of the slippery rails. In the trial it was shown that the company had rules in force requiring motormen to stop at the top of the grade approaching the railway, to keep the car under control in descending and to stop 30 ft. before reaching the crossing. Further precautions, including sanding of the track, were provided for slippery weather. The presiding judge ruled that the accident occurred through neglect of the subordinate employees to observe these latter precautions, and directed a verdict of acquittal for the executive officers of the company.

It is noteworthy that in the trial the fact that the responsibility for the safe operation of the road rested primarily on the Board of Directors of the railway company and on their executive officers was nowhere denied, and their acquittal was based on the ground that they had discharged this responsibility by establishing rules for the guidance of their subordinates, which if followed would have prevented the accident.

This accords with reason and justice; yet if an executive officer would seek not merely to escape responsibility for accidents but to leave no stone unturned to prevent their occurrence, he will not stop at the promulgation of rules. He will take pains to find whether these rules are strictly observed, will administer discipline for their neglect and will safeguard by mechanical apparatus wherever possible. At the Newark crossing, for instance, a derailing switch was brought on the ground, but it was never installed, and after some months was carted away because the electric railway company and the street railway company could not agree upon terms for its installation.

We believe that a law prohibiting the grade crossing of steam and electric railways except when protected by interlocking signals and derails is a much needed piece of legislation, and we are not sure that it would be still better without the exception.

When was wrought iron first used for the main members of bridges? In answer to this question we venture, without having made careful investigation, to suggest that the old Stockton & Darlington Railway bridge, built in 1823 over the River Gaundless, was the first for which wrought iron was employed for main truss members. A brief description of this bridge is published elsewhere in this issue, from which it will be seen that the top and bottom curved members or chords of the 12½-ft. girders were of wrought iron. The source of our information does not give the form or the dimensions of the sections of these members, but they appear to have been round bars of 2 or 3 ins. diameter. Taken altogether the construction of this bridge is most curious, and not the least curious feature of it is the combination made of cast and wrought iron. By the time that this bridge was built cast iron had become a familiar material in bridge construction, both in England and in Continental Europe, and such bridges had even been shipped for erection in the United States. It was not, however, until a decade or more later that wrought iron began to any considerable extent to replace cast iron in bridge construction. It is always venturesome to assert when or where an engineering material or design

was first employed, but there is some reason for thinking the Stockton & Darlington Railway bridge was the first to contain wrought-iron members, and we, therefore, submit its claim for that honor subject to withdrawal upon receipt of good evidence that there were previous claimants.

If the Stockton & Darlington bridge takes us back to the earliest beginnings of wrought-iron bridge construction, another structure which, fortunately, we are able to describe in this same issue is a reminder of the early days of wrought iron in building construction. Prior to the beginning of the nineteenth century wood and stone formed the strength of buildings, and iron was represented at most by a few cramps or anchors tying portions of the frame together. With the first few years after 1800 cast-iron beams and columns came into use to carry heavily-loaded floors; for fifty years cast iron held its place for this service and then gradually gave way to wrought iron, which material has in the half century since then created wholly new types of building construction. The old Bank of the State of New York, whose remarkable floor framing we describe in detail on another page, is no doubt among the first buildings in which wrought iron found extensive application. This was three decades after the Gaundless bridge of the Stockton & Darlington Ry. was built. That building construction lagged so far behind bridge work in making use of wrought iron may surprise us to-day, but it must be borne in mind that until recent years the types and methods of the two fields of construction were radically unlike. The birth of the I-beam in the early fifties first made available a compact and practical wrought-iron beam suited for general building purposes. The development of iron floor framing, and later the all-iron framing typified in cage construction followed with little delay. Even in the early wrought-iron floor which we describe, there is found a general arrangement that is quite modern in principle.

The details of the beamwork in the Bank of the State of New York building should receive interested study from structural engineers. The 10-in. floor joists, built up of thin plate iron, are of a form which certainly represents an excellent adaptation of the material to the desired purpose. We have not been able to discover the origin of this interesting form of beam, but we hope that our readers may be able to throw some light on its history. The main girders, with their peculiar connection of web and flanges, are less excellent; judged by modern standards at any rate, they are not permissible design. They are none the less interesting, however, and they may profitably be compared in economy with modern shapes, both riveted girders and rolled I-beams, of equal bending strength. The fact also that they have remained in service up to the present day without indication of failure must be accepted as vindicating the construction.

Lastly, we may point out that the excellent condition of the ironwork throughout this building, its virtual freedom from serious corrosion, is a notable addition to the accumulating testimony against the apprehensions freely entertained some years ago that our iron and steel structures are dangerously short-lived.

That much-talked-of "decay of New York's commerce," which is the corner-stone of the barge canal agitation, does not look much decayed in a report of the Bureau of Statistics just issued. In the fiscal year just ended the exports from the port of New York amounted to 505 million dollars, an increase of 158 million dollars over 1893. This compares with other Atlantic seaports as follows:

	Exports in millions of dollars in—		
	1893.	1903.	Increase.
New York	347	505	158
Boston	85	88	3
Philadelphia	49	73	24
Baltimore	71	81	10
Savannah	20	54	34
New Orleans	77	149	72
Galveston	37	104	67

In explanation of the large increase of the Southern ports, it may be said that it is in large part due to the high price of cotton in 1903.

In imports also, New York is far in the lead, her trade in 1903 amounting to 618 million dollars, while the imports at all other Atlantic ports combined were only 203 millions. The simple fact is that it is enormously difficult to alter existing channels of trade, and that New York's supremacy as the great gateway of foreign commerce is too firmly established to be seriously affected for a very long time to come by any possible changes.

To assign an arbitrary value to the product of any machine is a hazardous procedure; and to assign any such value to the machine itself is even more hazardous. In our issue of Aug. 27 there was published an article discussing the relative merits of concrete mixers, which was both interesting and instructive. Of especial value was the table showing the relation of the strength of concrete to the number of minutes occupied in mixing it. But at the end of the article was another table that we fear may prove misleading, despite the author's statement that the values assigned to the various "functions" of each type of mixer are arbitrary. A table of percentages, we think, should never be made unless those percentages depend upon definitely measurable quantities. Now, by this table of percentages the author has expressed in definite figures what he himself has previously said is merely arbitrary—and therefore indefinite. To say that one class of concrete mixer has a rating of 99%, while another has a rating of only 27%, is to give an appearance of exactitude to what is confessedly inexact. The author is not without precedent in making this table, it is true, but it is a precedent which we regard as being unscientific. We refer to the tables of percentages prepared to show the relative values of macadam, brick, wood, asphalt, etc., for street pavements. In such tables, cleanliness is given a certain rating, slipperiness another rating, durability another, and so on; the pavement showing the highest total is supposed to be the best. This percentage process in rating pavements, as in rating concrete mixers, is not scientific. The scientific rating of concrete mixers is determinable in one way only, that is by the dollars and cents standard. With a given expenditure of money for power, for labor, for installing and moving plant, for interest, for depreciation, and for materials, which mixer produces the most concrete of a standard strength? This question involves the element of uniformity of output, for if the output varies much in uniformity, then a concrete of "standard strength" is not produced. Under certain conditions the shovel and the man make the best concrete mixer, for where the concrete work is small in amount or thinly spread over a large area, this human machine is so cheaply moved from one place to the next that heavier competitors are distanced in point of economy.

The author of the article under discussion says:

> The best machine for practical work is that which will produce good concrete in large quantities with the least time and manipulation.

If our criterion of dollars and cents is the true one, then the "best" machine is not merely the one that will produce good concrete with least time and manipulation, for time and manipulation form only two of a number of elements that go to make up the total cost.

"Engineering is the art of doing that well with one dollar which any bungler can do with two, after a fashion," was the opinion of the late A. M. Wellington. We may add that the best machine, like the best engineer, is the one that turns out the maximum of product of standard quality at the minimum of expense for materials, power, interest and maintenance.

Up to the present time, so far as we know, there has been no comprehensive test of concrete mixers of different types, with dollars and cents as a standard of comparison.

A REVIEW OF THE RAILWAY TIE SITUATION.

The questions of the best character of ties for railway track and the means of securing a future supply of such ties, are of growing importance in almost every country. The wooden tie still holds its own, in spite of deterioration in quality and diminution in quantity of available timber, but one of the main reasons for its general use in this country is the fact that little attention has been paid to the tie from a practical or economical point of view until within very recent years. Steel ties are extensively used in many countries, and with satisfactory results, but there is a comparatively slight increase in their use, due in part to the fact that there is little railway development in some of the countries where they are in general use. The same is true of cast-iron "pot" ties, but an extended use of these latter is not to be expected. In the first place, such built-up ties are not desirable, and in the second place they are used mainly under special conditions of climate and soil to which they are peculiarly adapted. Concrete and concrete-steel ties have been tried, but the number of ties and the length of their service are entirely too limited to allow of any definite conclusions being drawn as to the outlook for concrete ties in general, or as to the merits of the particular designs which have been put in service. Of these substitutes for wooden ties we shall treat later.

In this country the use of wooden ties is universal, and as neither steel nor concrete as yet meet the immediate demands for a tie supply, the railways must of necessity continue the use of wood. The introduction of treated ties is extremely slow, as compared with the vast extent of railway mileage, although it certainly is making steady progress. As the capacity of existing tie-preserving plants is equal to but a small percentage of the total demand, the railways are further under the necessity of continuing the use of untreated wood, at any rate for some years to come. It is true that a number of such plants have been established quite recently by railway and lumber companies, in view of the approaching stringency in the supply of the better class of timber and the consequent economic necessity of using timbers which are unfit for use unless treated. But the capacity of existing and projected plants of this kind is far below the present requirements of ties for renewals and new construction. The railways, therefore, must seek to develop increased sources of timber supply as well as to develop methods of increasing the durability of the timber.

In this direction the United States Department of Agriculture is lending a helping hand to the railways. It is conducting experiments to ascertain the durability of ties of cheap and inferior timbers when treated by different preservative processes, and also to ascertain the ultimate economy in the use of these ties. It is also conducting experiments as to the practical and economic value of seasoning timber, a process which has been largely neglected in this country as far as ties are concerned, although it is a well-known fact that timber which has been seasoned is much more durable than the same timber put into service while still green. It is stated also that in view of the failure of sources of supply of the best tie timbers, several railways have applied for advice as to new sources of supply of such timbers, as well as of cheaper timbers which may be rendered economically serviceable by preservative treatment. The Department is, therefore, conducting investigation as to such sources of supply and the amounts of available timber.

As an instance of the changing conditions in the supply and price of ties, it is stated in a recent government report that the price of a hewed white oak tie in southern Illinois is 35 cts. (delivered on the right-of-way). But white oak timber will sell for more than twice this price for use as boards, staves, etc., and this difference in price will increase with the increasing demand and decreasing supply. It is therefore evidently poor policy to sell this timber at such a price for ties, and railways must consequently pay higher prices or find a cheaper substitute for oak. In the same report, it is predicted that at no distant time the supply of long-leaf pine for ties will cease, owing to its higher value for other purposes. There will then be use for the short-leaf, loblolly and other inferior pines which can be made sufficiently durable by treatment at a cost low enough to make their use economical. These cheaper and

inferior timbers are usually more susceptible to treatment than the better grades, which are usually more dense. But one of the pre-requisites for fitting these timbers for treatment is a proper seasoning.

In a recent report on the seasoning of timber* it is pointed out that although it has long been known that there is a marked difference in the life of seasoned and unseasoned timber, yet very little interest has been taken in this process, except for preventing the evils due to checking, warping and shrinking. Further investigation is needed, however, to determine more definitely the relation of seasoning to durability. By this process there is eliminated from the wood the water which feeds the growth of fungus (causing decay), but the process also involves other changes in the wood structure, which are not yet fully understood, but which have an important relation to the efficiency of subsequent preservative treatment. Of course, when timber is stored for seasoning there is a certain risk of loss, and the interest on investment is to be considered, but it is regarded as certain that the ultimate saving due to increased life and value will far outweigh these considerations. A series of investigations and tests as to the proper methods and actual results of seasoning have been instituted by the Department of Agriculture, in coöperation with certain railways and lumber companies.

Another point which we may now consider is that of taking steps to ensure a future supply of timber suitable for ties. At the present time very little is being done in this direction, railways as a rule still relying on a hand-to-mouth supply each year. Since the supply of hardwood timber for ties is admitted to be diminishing appreciably, it has been proposed to import foreign timber of this kind, notably the Australian hardwoods, the life of which is said to be from 20 to 30 years. Unfortunately, however, it is not certain that these timbers would prove so durable in this country, and we publish elsewhere an article describing some experiments in Mexico which have shown unfavorble results from Australian ties. It would appear that the highest results are obtained from certain definite species of timber, and that timber of approximately similar species will give lower results. In the purchase of foreign ties, therefore, the greatest care must be taken in the selection. Even then it must be remembered that while the natural life of the wood may be 20 to 30 years, the mechanical destruction due to spike-killing and rail-cutting may reduce the life very materially.

Another plan to ensure a supply of tie timber is to establish special plantations. Very little work of this kind has yet been undertaken in this country. Much of that which has been done has been on a very limited scale, and in several cases only unsatisfactory results have been obtained. These results, however, have been due partly to the selection of unsuitable timber, partly to improper planting or location, and largely to the failure to provide skilled attention for the growth and maintenance of the plantation. In the article above referred to will be found a statement of the tie plantation work undertaken by the management of the Cape Government Railways, in South Africa. Under the care of a skilled official in charge of the forest affairs, four plantations have been established, aggregating 8,000 acres, for both soft wood and hard wood. The latter is considered preferable, as it enables the additional expense of creosoting and steel tie-plates to be avoided. For this work the sum of $50,000 per annum has been appropriated for some years past, and the plantations are expected to eventually furnish a sufficient supply to meet the annual demand for tie renewals.

Within the past few years, the questions of improved quality of ties and of economy in the use of ties have been taken up actively by some railways and railway engineering associations. This movement, however, is but a small and tardy beginning. All these matters of investigation are commendable, but they are only in the initial stages, and it will be several years before any definite practical results can be expected. The necessity for investigations has been for years urged upon railway companies and managing officers, but they have (with a few exceptions) been content to care for the present alone, and to let the future take care of itself. It is only when they are driven to it that they begin to consider these measures of economy and protection. The great majority of American railways still continue to use ties in a reckless manner, maintaining little supervision over them when once they are laid in the track, and keeping no effective record or account of comparative service, cost, and ultimate economy.

Having discussed the present conditions and future prospects in regard to wooden ties, we may turn our attention to ties of other materials.

Since the abandonment of experiments with steel ties by the New York Central Ry., a few years ago, the number of such ties on American railways has been so small as to call for little attention, while results obtained from their use are quite inconclusive. In the very few cases where they have been tried, the railways have simply permitted them to be laid as an experiment by makers or inventors. In no case has the railway instituted experiments of its own or entered upon a practical trial of steel ties on the recommendations of its engineers, nor does any railway company or manager contemplate the adoption or extensive use of metal ties. We quote below two letters relating to unsatisfactory experience with steel ties:

(1) I beg to state that the steel ties which were tried on the Harlem Line have been disposed of as scrap. They were somewhat too light and would frequently break under the rail. It was also impossible to keep them in line and surface, at a reasonable expense. It was frequently necessary to surface them twice a month. All of the Hartford ties have been removed from the main track. Some of them are now used in passing tracks where engines clean ashpans. These ties were much heavier and did not break, but it was difficult to keep them in surface and line under high-speed trains. The labor required for this purpose was nearly double that required for wooden ties.—A. T. Hardin, Engineer of Maintenance of Way, New York Central & Hudson River R. R.

(2) The steel ties we had on this line have been out of the track for some time. We experimented with 44 of the Chester ties on a 2° curve for one year, including both cold and hot weather. They were made to fit 70-lb. rails, and as we were relaying this part of the line with 85-lb. rails we took the ties out and were to be furnished with heavier ones. Owing to the failure of the firm handling them these were never delivered. Our experience demonstrated that they stayed in line remarkably well, but required as much surfacing as (if not more than) the wooden ties, and some parts were not strong enough. I suggested some improvements which would have overcome the trouble and made, I think, a very good tie. During the time we had them in the track, the heaviest equipment of the Pennsylvania R. R., as well as our own, used it continually, but as the wooden tie is a very cheap article with us we had no view of adopting them even had they been satisfactory in all respects.—Carl M. Gage, General Manager, Huntingdon & Broad Top Mountain Ry.

Of course, these isolated and limited experiments really prove very little, and on the other hand we have the more favorable letter quoted below. But in this case most of the ties have been in use only a little over two years, and are not of a commercial design, being built up of plates and old rails riveted together, involving too much shop work for commercial manufacture.

Number of steel ties laid, 159; eight on May 1, 1900, and 151 on May 1, 1901. There have been no removals. The first ties weigh 150 lbs. each, with fastenings. The others weigh 250 lbs. each (with fastenings), and are constructed from a piece of worn-out 65-lb. rail with a steel plate ¼ × 8 ins., 8 ft. long, fastened on the head. The actual tie as designed will weigh about 60 lbs. per yd., and is to be rolled like an I-beam; top width, 3 ins.; bottom width, 8 ins.; depth, 5 ins. With metal at $20 per ton, this will bring the cost to $1.70 per tie. If the tie will last 20 years, the salvage value will be equal to at least half the first cost. No defects have been developed. The ties hold surface and line fully as well as, or in fact much better than, the wooden ties, and the gage is now as perfect as when the ties were laid. These ties have demonstrated under fast and heavy traffic that the construction and form are right, and the present indications are that they will last a lifetime.—C. Buhrer (Inventor), Roadmaster, Lake Shore & Michigan Southern Ry.

The concrete tie is of much more recent date than the steel tie in this country, and there has been even less experience with it, while its introduction has been on the same basis as that of the latter. In other words, its use has simply been permitted, and the railways have paid little or no attention to the matter. The concrete tie, however, appears to possess certain advantages over the steel tie. In the first place, it has a greater bulk and weight, and there is no difficulty in obtaining sufficient weight for stability without reaching too high a cost. Two recent forms of reinforced concrete ties weigh 250 and 436 lbs., and their cost is given as $1.25 and $1.30, respectively. In the second place, the manufacture is much simpler and requires less expensive plant, even for manufacture on a commercial basis. There is also less dependence upon market conditions than is the case with the steel tie.

Concrete alone would probably prove strong enough, but several designs for reinforced or concrete-steel ties have been made, and a few such ties have been put in service. The steel is usually embedded in the concrete, and intended to increase the strength of the tie longitudinally, or as a beam. In one particular form, however, the tie consists of two concrete blocks connected by steel beams whose ends are embedded in the concrete. It may be noted here that some concrete ties have wooden blocks to carry the rails and serve as spiking blocks. Their purpose is to give a certain elasticity to the rail support, but they present some objections. In the first place, it is difficult to attach the wood so solidly to the concrete as to make a homogeneous structure (especially as renewal must be provided for), while the more the track can be built up as a homogeneous structure the better. In the second place, the use of the wood blocks generally means the use of the old and inefficient spike. While there seems to be little prospect of the introduction of an improved rail fastening, it is certainly not desirable to provide for perpetuating the spike (with its many defects) in new forms of ties which are intended to effect an improvement in track construction. In fact, one of the best features of the steel ties so largely and successfully employed in other countries is the efficiency and permanence of their rail fastenings.

In view of the conditions of the timber supply and consumption, and in spite of the work of timber preservation and reforestation which has been started, it seems not improbable that steel or concrete ties will ultimately come into general use, largely in conjunction with a general improvement in track construction. The trials of steel ties in this country thus far have been on so small a scale and made under such conditions that their results are of little use in determining the real efficiency of the steel tie, or the best form for such a tie. But the failures of most of these small experiments have often been spoken of as indicating or proving the inefficiency of steel ties in general.

In Europe, where steel ties are extensively used, and where their manufacture is an important item in the steel industry, many years of trial and experience and many thousands of ties have been expended in arriving at the design of a practically and economically successful tie and rail fastening. But in Europe, India, and other countries where steel ties are extensively used, these experiments and experiences have been conducted by and under the supervision of the engineers, with authority from the managers and higher officials. No such condition has as yet existed in this country. When the tie question reaches such a point that it compels the attention of managers of American railways, the engineers will be permitted or directed to take up the matter thoroughly and not as an insignificant side issue.

If the use of wooden ties is still to be universal, it is time that active steps were taken to ascertain comparative efficiency, sources of future supply, and means of getting the maximum service for minimum cost. If some other material is to take the place of wood, in part at least, it is time that active steps were taken to investigate and experiment with such substitutes, in order to determine the material, form, etc., which will give the

*"Seasoning of Timber," by Hermann von Schrenk, Bureau of Forestry, Bulletin No. 41, U. S. Department of Agriculture, Washington, D. C.

highest efficiency and economy. In either case, these investigations should be instituted by the railways themselves and entrusted to their engineers, instead of being left entirely to the enterprise or interests of manufacturers, dealers or inventors, who very frequently have little comprehension of the practical or economic questions involved in the tie question.

LETTERS TO THE EDITOR.

Waterproofing a Sandstone Obelisk.

Sir: Can you give me the name of any dealer who sells a mixture designed to be used as a coating on stone or brick masonry for the purpose of rendering it waterproof? It is proposed to treat the surface of the Floyd Monument, an obelisk 100 ft. high, built of Minnesota sandstone, with a material of this kind, if it can be found. The stone has a great absorptive capacity for water and after rainy weather retains a wet appearance for a long time. It is desired to prevent this if possible, and I would like to obtain some substance which could be applied to the outside so that it will soak into the pores and harden in the stone. Very respectfully,

H. M. Chittenden, Captain, Corps of Engrs., U. S. A.
U. S. Engineer Office, Sioux City, Ia., Sept. 1, 1903.

(Several of our advertisers offer preparations for waterproofing masonry. Where it is necessary that the color and general appearance of the surface shall remain unchanged, as in the case of a monument, we believe that melted paraffine applied to the stone after heating has been frequently used, notably on the Egyptian obelisk in Central Park, New York. The stone is heated with gasoline torches, care being taken to avoid such local heating as to crack it, and the melted paraffine is brushed over it. Afterward the torches are again applied and any surplus paraffine is thus burned off and the remainder is driven in the pores of the stone. Press dispatches state that this process is now being used to preserve the sandstone foundations of the Washington homestead at Mt. Vernon which have been crumbling badly. We shall be glad to hear from any of our readers who can furnish a more definite statement from experience in waterproofing of this sort.—Ed.)

The Schlicht Process of Combustion Again.

Sir: A copy of your issue of Aug. 20 has come into my hands, in which, on p. 162, you are kind enough to give a reading notice of a coal-saving device which we are introducing in many large and important manufacturing plants in the country.

I find an element of skepticism running through the article referred to, and while I realize that one "must not look a gift horse in the mouth," I am in the position of the man who does not like "to be damned with faint praise."

I take occasion to hand you a little pamphlet having to do with an apparatus which we attach to house furnaces, and take the liberty of calling your attention to an extract from a letter written by the late Dr. Henry Morton, President of the Stevens Institute of Technology, and experiments made by him. We are taking advantage of the principle to which his letter refers, and that we may satisfy you of the truth of said statement, we hold ourselves in readiness at any time to put one of our "Savanthracites" on a furnace, steam heater, hot-water heater, or any other heating apparatus in the house of anyone connected with your publication, that he may himself, by practical use, have demonstrated to him the truth of the underlying principle of our device.

Beyond this, we should be very glad to show you a furnace surrounded by isinglass, through which the truth of the downdraft can be easily seen, opposed to the natural updraft through the chimney, our apparatus being attached to the smokepipe, a lighted torch held at the opening of same, producing smoke, the course of which can be followed through the smokepipe, down and around the passages of the furnace until it reaches the combustion chamber.

We hold ourselves in readiness, too, to prove the existence of a current of air through the lower tubes of a return tubular boiler back to the fire, while the gases are escaping through the upper line of tubes to the stack.

You have been kind enough to give us the notice in a prominent place on your editorial page, for which we are very grateful, but through it all there seems to be an element of doubt. It will be our pleasure, if you so desire, to refer you to a number of plants where our apparatus is in successful operation. Yours very truly,

E. C. Hovey, President.
The Coal Saving & Heating Co., 500 Fifth Ave.,
New York City, Aug. 26, 1903.

(The pamphlet to which the above letter refers states that the "appliance works under a principle patented and controlled by the Schlicht Combustion Process." If we mistake not, the statement by the late President Morton, to which reference is made, was made by him in testifying as a patent expert, in a suit for infringement brought by the Schlicht company. The Schlicht process was described and commented on by us in 1899,* when it was first exploited.—Ed.)

Acetylene Gas for Lighting Steam Shovels.

Sir: Can you give me any information about the use of acetylene gas for the lighting of steam shovels?

I desire to know whether acetylene has been successfully used for that purpose, and what the different generators are, and I wish also to get information as to methods, safety, and reliability, and as to cost of operation. We have used gasoline torches with Wells lights as a combination. We have also a number of our shovels equipped with electricity. None of these is satisfactory. The chief trouble with electricity is the heavy drain put upon the boilers by the dynamo. We use about twenty 16-c. p. lights and generally they are very dim. All steam-shovel boilers with which I am acquainted are barely capable of furnishing power for their own work, consequently it is of no use to put in larger dynamos. The Wells light, and others of its kind, I suppose, is difficult to regulate and keep the burners in proper condition. Torches are poor Any information you can give that will help us secure a more satisfactory light will be gratefully received. Yours truly,

M. Woolsey,
Lorimer, Gallagher & Walsh Cons. Co.
Cedar Falls, Ia., Aug. 28, 1903.

(We have no record of the use of acetylene gas for lighting steam shovels, but see no reason why it should not prove excellent for this purpose. A number of strong, compact and durable acetylene gas generators have been designed and very successfully used for supplying locomotive headlights and some of these at least would seem to be well adapted for use in connection with steam shovels. A very simple system of piping, with jets at the requisite points and reflectors provided where it is desirable to project the light onto the bank, spoil cars and surrounding ground, would suffice for distributing the gas from the generator. In our issue of Dec. 12, 1901, we described the locomotive headlight generator built by the Railway Supply Co., of Chicago, Ill., and in our issue of July 24, 1902, we described the acetylene headlight built by the Rushmore Dynamo Works, of Jersey City, N. J.—Ed.)

Eye-Bar Chain Bridges and Tests of Nickel Steel Therefor.

Sir: Referring to the letter of Mr. Henry Szlapka, published in your issue of Aug. 13, I would like to state the following on "Engineer's Reports and Chain Cables for Large Suspension Bridges."

The problem of painting a large assemblage of eye-bars does not present any more difficulty for the Manhattan and Blackwell's Island bridges than it does for any other long span truss. With proper care, the bars and their heads can be well painted and protected, as it has been done, successfully, in many instances.

As to the appearance of a well-built chain bridge, it may well be remembered that the chain bridges count amongst the most beautiful structures of this type. The prominence and strong outline of a wide chain indicates the main supporting member of the bridge clearly to the observer. No doubt arises in his mind whether the truss is supported by the cable, or whether the truss is the main member, and the cable has an auxiliary function only. Clearness of æsthetic outlines is not difficult to obtain with comparatively short spans and single-deck structures, but with long spans and traffic requiring double-deck bridges, the depth of the stiffening trusses cannot be reduced below a certain minimum. This least depth of the truss is still too deep for good appearance, and the truss will appear to be self-supporting, relegating the necessarily small cable to a second place. Quite different is the case with a long span eye-bar bridge. Here the observer will see against the sky a strong and mighty line which will clearly tell him the function of the chain.

The Municipal Art Commission, which consists of men devoted to art, and representing most of the branches of applied art, has approved the general plans, and there seems to be little doubt that the proposed plans for the Manhattan Bridge will prove to be æsthetically very satisfactory.

The size of eye-bar proposed to be used is of a width of 18 ins., and a maximum thickness of about 2 ins. The greatest sectional area of one chain is 610 sq. ins., and the least 538 sq. ins. A very simple computation will show that a greatest width of about 70 ins. will be required per chain, varying to a least width of about 62 ins. The number of bars will vary between 18 and 16. The specifications for the steel superstructure of the Blackwell's Island Bridge, for which bids are advertised for Sept. 24, specify that no variation will be allowed from the required lengths between centers of pin-holes, exceeding 1-64-in. for every 40 ft. It is well known that such accuracy can easily be obtained in any well-equipped shop. As the lengths of the bars in the cables will vary from 42 ft. to about 48 ft., the limit of accuracy is well fixed. To stretch a steel bar 40 ft. long 1-64 of an inch requires a stress of somewhat less than 1,000 lbs. per sq. in., as the bars are required when annealed to show, on full-size tests, a minimum elastic limit of 48,000, and an ultimate strength of 85,000 lbs., the difference in stress between the bars would be 2% of the elastic limit, and about 1.2% of the ultimate. Evidently there is no danger of some bars being stressed much higher than the rest.

It is true that the condition of the material in large eye-bars cannot be judged very closely by the results obtained from small test pieces of the same material, but Mr. Szlapka might have added that the trouble referred to is found as often in the body of the bar, away from the points where it has been heated for upsetting and forging the heads, as in the portions thus heated. This difficulty in thick eye-bars is well recognized in ordinary carbon steel eye-bars, and the small test pieces have been found insufficient to show the true character of the material. For that reason, full-size bending tests of the bars as they come from the rolls are called for in the recent specifications of the Engineers of Maintenance of Way. These bending tests of full-sized bars are considered the best check we have to-day on material likely to give the trouble referred to by Mr. Szlapka, and the writer does not think that bars which have successfully complied with these tests have given subsequent trouble in tension tests of the full-size eye-bars. With these facts in view, and in order to test the upsetting, forging of heads and annealing, 21 full-sized eye-bar tension tests were made by the Fencoyd plant of the American Bridge Co., on nickel steel eye-bars manufactured by the Carbon Steel Co., of Pittsburg, of the following sizes:

4 eye-bars 6 × 1 ins.	6 eye-bars 8 × 1¼ ins.
5 eye-bars 6 × 2 ins.	6 eye-bars 10 × 1¼ ins.

All these eye-bars broke in the body of the bar with very satisfactory results.

In addition to these eight full-sized eye-bar, tests of nickel steel were made on bars manufactured by the Carnegie Steel Co., of the sizes 6 × 1½ ins., and 6 × 2 ins., and tested by Mr. W. R. Webster, M. Am. Soc. C. E., whose report was duly submitted to the Commission of Engineers on the Manhattan Bridge, and the requirements in the specifications are based on the results obtained.

In order to compare the results of nickel steel in extremely large bars, two nickel-steel bars were rolled at the works of Carbon Steel Co., Pittsburg, Pa., 18 × 2 ins., by about 25 ft. long, and 18 × 2¼ ins., by 62 ft. long. The percentage of nickel was 3.11 and 3.53 respectively; that of carbon 0.36 and 0.34. Test pieces were cut from different portions of these bars, and gave satisfactory results. As will be noticed, the thickness of the bars represented the extreme limits required, and the test specimens therefor had received the same amount of rolling and squeezing as did the full-size bars. Bending tests of full thickness also gave good results.

In order to check the character of the nickel steel for large eye-bars, the specifications for the steel superstructure of the Blackwell's Island Bridge (see illustrated description in last week's issue—Ed.) call for the following bending tests, in addition to the chemical requirements and physical tests of small test pieces:

> The full-size unannealed bar must bend cold 180° around a pin with diameter equal to three times the thickness; the finished annealed eye-bar must bend cold in the neck of the bar 90° around pin with diameter equal to 2½ times the thickness. In addition to this, pieces from three bars of each melt of eye-bar steel shall be cut 18 ins. long and not less than 4 ins. wide, and after annealing with the finished eye-bars, shall bend cold 180° around pin equal to twice the thickness.

This test is to check the annealing of the bars on each heat of steel, and is in addition to the full-sized tension tests which are called for, the latter requiring to break in the body and to give the ultimate strength quoted above.

As to the upsetting of large sized bars and their subsequent annealing, exercise of care will be required. With up-to-date upsetting and forging machine, performing the whole work at one heat, and proper care exercised in the annealing of the bars, as specified in the Blackwell's Island Bridge specifications, no difficulty is expected to be encountered by manufacturers best entitled to an opinion. To the writer's knowledge, eye-bars 14 ins. wide and 2 to 2½ ins. thick are at present being manufactured in one of the bridge shops, and they do not offer any extraordinary difficulties. In these bars bends are made with the full thickness of material before bars are accepted for upsetting. Yours respectfully,

Leon S. Moisseiff, Assistant to Commissioner.
Department of Bridges, New York, N. Y., Aug. 24, 1903.

*Vol. Jan.-June, 1899, p. 110.

Notes and Queries.

The article on "Bridge Destruction in the Kansas City Floods" referred to on the bulletin at the top of the front cover page of this issue is postponed to our next week's number because of a delayed cut.

P. R. C., Lebanon, Pa., asks whether it is not incorrect to use the word "grade" to denote both elevation and inclination, and whether "gradient" is not the correct term for inclination.

"Gradient" is used in England, but is not in common use in this country. By the "Century Dictionary" the use of "grade" is correct for both the elevation of a point and the inclination of a line, and this corresponds with common usage among engineers.

RAILWAY TIES AND TIE PLANTATIONS IN MEXICO AND SOUTH AFRICA.

The railway tie question is one of increasing importance in this country, both in regard to the efficiency of the ties themselves and in regard to the sources of future supply. In our editorial columns there is presented a review of the tie situation, and herewith is given some information relative to experience in two countries which have not a good or sufficient supply of timber suitable for ties.

MEXICAN SOUTHERN RY.

This railway (3-ft. gage) is using mainly steel and native oak ties, and on the main line from Puebla to Oaxaca, 289.54 miles, there are two sections (88.66 miles in all) laid with oak, and the two other sections (200.88 miles) are laid with steel. The native ties have a life of about five years, and the question of renewing all these with ties of a more durable material is now under consideration.

The rails on the Mexican Southern Ry. are of steel, T-section, 50 lbs. per yd., laid to 3-ft. gage. The minimum radius of curve is 330 ft., and the maximum grade is 4% (on the mountain division). The length of main line is 227½ miles, of which 43½ miles are in a very crooked canyon. On 20½ miles of this canyon are wooden ties 23 ins. c. to c., while on 23 miles there are steel ties 28 ins. c. to c.

Of the main line, 139 miles were laid in 1891 with pressed steel trough ties, similar to the Rendel type, 5 ft. 5 ins. long, weighing 64 lbs., and spaced 28 ins. c. to c. Lugs are punched up from the top of the tie, and the rails are secured by steel keys or wedges (of Livesey's design) driven between the lug and the base of the rail. The ties were given a tar bath when new, and after 11 to 12 years of service only a very few have been removed or found defective; the removals were on account of rapid oxidation in saline and sulphurous soil, and a few ties were broken at the rail seat, on account of defective design and lack of proper care. They have proved a great success so far, and appear likely to last 12 years longer, at least, without another coat of tar. In fact, the engineer believes that they would last indefinitely in that climate if given a coating of tar at intervals of 12 or 15 years.

The other 88½ miles of the main line were laid in 1891 with native oak ties, 6 × 8 ins., and 6½ ft. long. Goldie steel spikes 9-16 × 5 ins. were used, and no tie-plates have yet been placed. On sharp curves, two pressed steel rail braces per rail have since been put on, and two more per rail are now being added. About two years ago some 26,000 Australian jarrah and karri ties (about half of each) were laid in among the oak ties in renewals. Besides these there are several rail lengths of jarrah ties entirely, both on curves and tangents, in cuts and on banks, so that later on some conclusions can be drawn as to their durability. These ties are 5 × 8 ins., 6½ ft. long, and holes were bored for the spikes, as a precaution against splitting. There are 22 miles of the wooden-tie track in a narrow box canyon, with a maximum grade of 4%, and the majority of the curves are of only 328 ft. radius, some even less than this. The ties are 23 ins. c. to c.

The locomotives used are American Baldwin consolidation engines, with 80,000 lbs. on the drivers (27,000 lbs. on the rear pair); also some English tank engines, which are more severe on curves, as to spreading of gage, than the American engines. The rainfall is from 30 to 60 ins., mainly from April to October, with very little rain from October to April. The traffic consists of two trains each way daily. Great difficulty has been experienced in preventing the spreading of track, even when laid with good oak ties, double spiked, and with two rail braces to each 29-ft. rail. This is especially the case in wet weather. In fact, the combination of consolidation engines and very sharp curves (328 ft. radius, and even less), makes it very difficult to prevent spreading, without the use of tie-plates or a large number of rail braces.

Contrary to expectations, the Australian ties do not appear to be any harder than the native oak ties, and it is considered doubtful whether they will hold the gage or resist wear better than the native oak. Their life, therefore, must be reckoned by the time they will resist wear and spike-killing, rather than by the resistance to natural decay, and it is evident that they must be protected by tie-plates. A nursery of jarrah (eucalyptus marginata) has been started from seed obtained in California, and it is proposed to give this timber a trial in the canyon to see if it will thrive.

Australian Jarrah Ties on the Mexican Southern Ry.
(Showing the cutting of the ties by the rails after two years' service.)

Photographs sent us of jarrah ties on curves of 330 ft. radius, after rather less than two years' service, show that the ties are beginning to be cut by the rail, and that they will soon be "spike-killed" unless tie-plates are put on. These are not extreme cases, as there are ties in even worse condition, and some ties are already plugged where the spike has been forced out. The spikes used are of the Goldie pattern, steel, 9-16 × 5½ ins.

The matter of renewing all the native oak ties with ties of a more durable character was taken up by the directors, in England, some months ago. The General Manager, Mr. W. Morcom, then instructed the Resident Engineer, Mr. T. A. Corry, M. Am. Soc. C. E., to make a comparative estimate of cost, durability, etc., of steel, oak, jarrah and karri ties. The statement prepared by Mr. Corry is given in the accompanying table.

Comparison of Steel and Wooden Ties; Mexican Southern Ry.

Items.	Steel.	Karri and Jarrah —, With tie-plates.	Karri and Jarrah —, Without tie-plates.	Native oak.
First cost (gold)	$1.67	$1.37	$1 25	$0.24
Estimated life, years	25	16⅔	12½	5
Number of renewals in 50 years	2	3	4	10
Estimated cost per renewal	$0.04	$0.05	$0.04	$0.04
Interest on first cost per tie, 6%	7.515	8.22	9.375	3.96
Interest on renewals, per tie, 6%	.180	.30	.30	.66
Total interest for 50 years, 6%	$7.695	$8.52	$9.675	$4.62
Section forces, foreman	1	1	1	1
Section forces, laborers	3	..	..	6
Length of section, kilos	15	..	..	10
Cost per gang per day (Mexican silver)	$3.00	..	..	$4 50
" per kilo. per year (Mexican silver)	62.00	70.00	80.00	139 50
" labor per year, per kilo. (gold)	23.75	26.82	30.65	53.45
" interest charges at 6%, avg. per year per kilo, 50 yrs.	230.85	255.00	290.25	138.60
Total cost per year per kilo. (gold)	254.60	282.42	320.90	192 05
" cost per kilo. (1,500 ties) (gold)	2,505.00	2,055.00	1,875.00	360.00
" cost per kilo. for 50 years	17,740.00	20,286.00	23,545.00	13,702.00
Total annual cost per kilo. for 50 years (gold)	354.80	405.72	470.90	264.05

The chairman of the board of directors did not agree with the figures as given in this estimate, claiming that the jarrah and karri ties would last very much longer than 16 years, and would hold the rails firmly, so as to prevent spreading. We find that the dealers in these woods claim a life of 30 years, but the experience of railways using such ties appear to indicate a maximum life of about 20 years under favorable conditions. The real Australian jarrah ties are said to be very hard, tie-plates not being needed, but the jarrah ties in Mexico seem to be very inferior in this respect. In the "Report on Metal and Wooden Ties" prepared for the U. S. Department of Agriculture, by a member of the editorial staff of this journal, and published in 1894, it is shown that on the Southern Mahratta Ry., of India., Australian karri ties laid in 1886 had to be renewed in 1894, owing to decay from excessive moisture. In the northern part of the colony of South Australia, jarrah ties were used at switches and on bridges (where steel ties were used on the open line), but many failed in from 5 to 7 years by wet rot. The annual rainfall was 60 ins. They were also liable to destruction by white ants. In the southern (and arid) part of the colony, 20 years is given as the life of jarrah ties, and it would appear that this is a longer life than can be expected in Mexico, judging from the experience above noted, especially if the ordinary inefficient and troublesome spike is to be used. The steel ties would appear, therefore, to rank above any of the wooden ties, both in efficiency and economy.

It may seem at first rather surprising that the engineer did not in his report consider the preservative treatment of the native oak ties. Many American railways are now getting good and economical results from cheap and inferior timbers treated by some preservative process, and the Mexican Central Ry. has established a tie-treating plant of its own. Mr. Corry informs us, however, that the road uses only about 4,000 ties per month, and thinks this would be too small a number to justify the erection of a creosoting or other preservative plant. It is thought probable, however, that a well-creosoted tie, either of pine or oak, would give as good results as the Australian jarrah or karri, and at less cost, tie-plates being used in either case.

As a result of the comparative estimate given above, Mr. Corry recommended the continued use of native oak ties, until the rate of exchange and price of steel ties should be favorable enough to warrant investment in the latter. He would use, however, steel ties similar in style to those now in use, but larger, heavier and stronger. These would also have a U-bolt fastening, with reversible clips held by nuts, the horizontal leg of the bolt lying within the tie. This has been designed with a view of correcting defects in the present ties, which are weakest at the rail seat, on account of punching out the lugs for the fastenings. In the absence of definite information or experience as to the durability of the jarrah and karri ties, Mr. Corry prefers the steel, on account of increased safety, no danger from fire, and low cost of maintenance. In 1891, the steel ties cost, delivered, $1.42; and the oak ties 90 cts., both Mexican silver currency. This was very different from the present prices of $1.67 and 24 cts., respectively.

CAPE GOVERNMENT RAILWAYS, SOUTH AFRICA.

In the annual report of Mr. T. S. McEwen, General Manager of the Cape Government Railways (Cape Colony), South Africa, it is stated that there is a continued falling off in the supply of colonial wood for ties, which is variously attributed to scarcity of suitable timber, want of transportation facilities, and more profitable utilization of timber in car and wagon building. In consequence of this, supplies have had to be obtained from outside sources. With a view to this contingency, his predecessor, Mr. Elliott, established forest plantations of jarrah and other suitable timbers to meet the future requirements of the railways, and Mr. McEwen recommends the continuance of the expenditure of $50,000 annually on this account. On these railways, wrought-iron

ties were at one time used quite extensively, but these are now gradually being replaced with wooden ties. In 1902, there were 4,174 metal ties removed, and 2,929 in 1901. Heavy renewals will be required, however, to eliminate all the metal ties.

In regard to the plantations for tie-timber we give the following abstract of the report of the Conservator of Forests:

On a basis of 2,100 miles of railway open in 1902, and 2400 ties per mile, and a ten years' life of ties, there will be required yearly in round numbers 420,000 ties, or say 1,000,000 cu. ft. of tie timber in Cape Colony. The average cost is $1.25 per tie. Assuming a mean yearly timber yield per acre of 200 cu. ft. for eucalypts and 100 cu. ft. for pines, the following four plantations have been laid out to provide the 1,000,000 cu. ft. required yearly: For eucalypts, Knol Vley, 2,500 acres; Elgin, 1,000 acres; total 3,500 acres. For pines, Helderberg, 1,000 acres; Epping, 2,000; Knol Vley, 1,500; total 4,500 acres. Grand total, 8,000 acres.

Besides being strong and free from minor defects, the hardwood timber required for tie plantations here must fulfil the two qualities of being durable and quick growing. As best fulfilling these conditions, I selected the following: Ironbark (Eucalyptus paniculata), tallow-wood (E. microcorys), red mahogany (E. resinefe.a), saligna gum (E. saligna), blackbutt (E. pilularis). The jarrah (E. marginata) is being planted sparingly on account of its slower growth. Care will have to be taken that the jarrah ties are not confounded with karri or West Australian red gum (E. calophylla), both of which grow in the same forests as jarrah, and are inferior as tie timbers. The report of the Public Works Department of New South Wales gives the following durability list*:

Ironbarks*	30 to 50 years.
Tallow wood (E. microcorys)	24 " 35 "
Grey box (E. hemiphloia)	25 " 40 "
Brush wood (Tristania conferta)	20 " 30 "
Gray gum (E. punctata)	30 " 40 "
Blackbutt (E. pilularis)	20 " 30 "
Red mahogany (E. resinefera)	25 " 35 "
Spotted gum (E. maculata)	15 " 20 "
Saligna gum† (E. saligna)	15 " 20 "

*The ironbarks are: E. paniculata, E. sideroxylon and E. sideraphloia.

†Other lists place the saligna gum higher. There are two varieties.

Soft Wood.—Cluster pine (pinus pinaster) plantations are raised by the inexpensive process of plowing and sowing broadcast. Pine is used on those portions of the plantations where the soil is too poor and sandy to furnish a good growth of hardwoods.

Hard Wood ties are more profitable, for three reasons: (1) They are produced from eucalypts, growing more quickly than pines; (2) they save the cost of creosoting; (3) they save the cost of tie-plates.

PLANTATIONS.—At Knol Vley, 3,176 acres have been plowed and 57,333 young trees planted, supplied from the existing nursery. A new nursery, containing 826,500 young trees, has been established. At Elgin, 229 acres have been plowed, and a nursery established, with about 750,000 young trees. The soil is a red loam, and the rainfall 50 ins. About 80 acres have been sown with cluster-pine seed, while gum and pine seed have been sown in the nursery and 1,200 ash trees (Fraxinus americana) have been planted. At Helderberg, on the sandy Cape Flats, some ground has been broken with a steam plow. At Epping, also on the Cape Flats, 106 acres have been plowed. This plantation will consist mainly of pines, with fire lines of eucalypts.

The Engineer in Chief, Mr. J. Brown, in his report for 1902, refers to the insufficient supply of native timber for ties, and makes the following remarks:

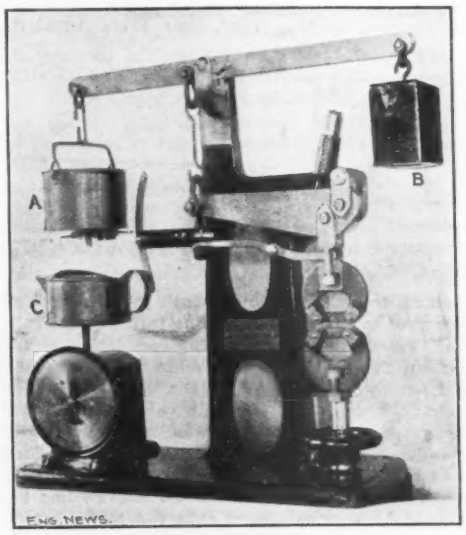
Large quantities of jarrah (E. marginata) have been obtained from Western Australia, and also djatti (a species of tectona) from Java. Both of these timbers have so far given good results. Ties treated by the Haskinising process were laid at four different localities. The result so far has not been satisfactory, but it is perhaps premature to make a definite report, as in one locality the results have been very different from those obtained in another.

*This list represents the natural life of the timber and not the life of ties subjected to various destructive effects from rails and spikes.

AN IMPROVED FORM OF AUTOMATIC CEMENT TESTING MACHINE.

The only automatic tensile testing machines for cement that have gained much favor with engineers are those in which the load is applied by running shot into a pan or bucket attached to one extremity of a system of levers at the other extremity of which are the briquette clips. All of these machines require a separate operation for weighing the load of shot, and in all of them the actual breaking load is slightly falsified first by the weight of the shot which are falling through the air at the moment of fracture and secured by the impact of the falling shot on the pan or bucket. To obviate this separate weighing of the load and to prevent its falsification in the manner indicated a new form of automatic cement testing machine has recently been patented and put into use. A view of this machine ready for operation is given in the accompanying engraving.

In this machine the bucket A containing 15 lbs. of shot is exactly counterbalanced by the weight B, and the lever system is in equilibrium with no



Machine for Automatically Testing the Tensile Strength of Cement Briquettes.

strain on the briquette. As soon, however, as the shot begin to run from the bucket A into the scale pan C, the excess of the weight B begins to exert a pull on the briquette. This pull at any moment is, of course, exactly equal to the weight of shot which has escaped from the bucket. As soon as the pull breaks the briquette the lever holding the upper clip flies up and shuts off the escape of the shot from A. A glance at the pointer of the scale into whose pan the escaping shot have fallen gives the weight of the load under which the briquette broke. The shot in the scale pan are then poured back into the bucket A, a new briquette is adjusted, and the machine is ready for another test. A spring scale is recommended by the makers of the machine, but of course a beam scale may be substituted if desired. If a beam scale be used, however, a separate operation is necessary to adjust the poise or apply weights, and it is thought that this disadvantage more than counterbalances any objection that may be had to a spring scale, particularly as the latter is supplied with an adjusting screw which enables the spring to be adjusted and tested by known weights as often as desired.

The special advantages claimed for this machine are of course that it saves a separate weighing operation and prevents any falsification of the actual breaking load. There are certain other advantages as well. One of these is the improved form of "shut-off" which cuts off the escaping stream of shot practically at the instant the briquette breaks. Another is that the grip and entire apparatus are so rigid and free from deflection under maximum load that a very small travel of the weight on the end of the lever develops the full capacity of the machine. The necessity, therefore, of taking a second hitch on the briquette, or putting on additional weights, or any other resort of that nature, is avoided and the test is absolutely automatic from start to finish.

The machine as described has a capacity of 1,000 lbs. It is manufactured by the Falkenau-Sinclair Machine Co., of Philadelphia, Pa., to which we are indebted for the information from which this description has been prepared.

STEEL PRODUCTION THREE DECADES AGO AND TO-DAY.*

By Andrew Carnegie.†

It is 29 years since the Institute held its autumn meeting at Barrow. I have recently looked over the proceedings of that notable meeting. These seem to carry us back almost to the very beginning of cheap Bessemer steel manufacture in America, in which as usual Britain was the pioneer and taught the younger Republic. It was at that meeting your fellow member and Bessemer medalist, Alexander Lyman Holley, then our engineer from the Carnegie Steel Works, read the two papers which first brought to your attention the doings of your American brethren in developing the Bessemer process you had given them.

There are several here to-day who were then present. Such was the impression made upon the meeting that after the discussion, in proposing a vote of thanks, our Nestor, Sir Lowthian Bell, as president, said: "There was no doubt that in America they were doing great things in the manufacture of Bessemer steel, and their friends on the other side of the Atlantic were not averse to telling them what they did, and not only what they did, but how they did it. He thought, under the circumstances, if any member of that Institute was entitled to the thanks of the meeting it was the gentleman who had just read the last two papers."

The effect of these papers, as you know, is a matter of history. Josiah T. Smith, of Barrow, one of the greatest of your managers, and subsequently president of the Institute, characteristically said that Mr. Holley would find that, as far as Barrow was concerned, "They would try and do as well, in regard to quantity, as the United States," which struck the right note. There spoke the true Briton, who has done according to his means more than any other, the American not excepted. The record of the great little mother of nations is not equaled by any of her children, although her oldest and biggest seems to inherit its mother's indomitable spirit and the ability to work miracles. In all matters of iron and steel, however, the child has been borne upon the shoulders of the parent. If the Atlantic Ocean had been prairie land, there would have been little left in the world but the conquering old lady and her family, all under one roof, under one flag of a self-sustaining Empire under free trade with probably 200,000,000 of our English-speaking race, and a home market so big as to give control of neutral markets. No question of protection or preferential tariffs then to disturb us; besides all this we should have been able to enforce peace among nations.

Gentlemen, unfortunately an ocean exists where we should have preferred prairies, but it is traversed in about the same time as the 3,000 miles of land between Montreal or New York on the Atlantic and San Francisco and Victoria on the Pacific. Who so bold as to predict that never is our race to succeed in converting the ocean, hitherto a barrier to your extension, into the pathway to reunion of the two once united branches? Not I! My faith is unshakable that some day this will be accomplished, and that instead of being two small islands here alien to the European Continent you will look across the sea to your own children in Canada and the United States, and become once more the mother member of the dominant power of the world. It would have been a case of Britain versus all the rest of the world, the world kicking the beam.

Mr. Whitwell participated in the discussion, and asked Mr. Holley to give his opinion on the "from one-half to three-quarters more product which could be got from the converter in America than we were getting in England," which Mr. Holley answered after reading his second paper. It was chiefly owing to his own invention of bottoms in reserve and removable appliances.

There was also at this historical meeting a report, a remarkable production, submitted by David Forbes, foreign secretary to the Institute, upon the progress of iron and steel industries in foreign countries. I naturally turned to see what he had to say about the United States. Several pages are given to the Pittsburg district, and what is there recorded carries me back to the days of youth, apparently. In 1873 the Pennsylvania Steel Company made 20,000 tons of steel rails. They make that amount in two weeks now. Bethlehem Iron Works were engaged in raising a loan of the enormous amount of £20,000 for the extension of their works, a paltry $100,000. Five millions would be comparatively less to-day. The great Cambria Iron Works in Western Pennsylvania, near Pittsburg, were credited with having made no less than 1,027½ tons of ingots in the week ending September 26, the largest quantity ever made in a week—a day's work nowadays. Two new blast furnaces were being built in Ohio, the capital of the company being all Scotch, and it was proposed to call the iron Scotch-American pig. This isn't a bad brand—either of men or iron. It is noted that the total production of pig iron in the United States in 1872 was 2,897,000 net tons, and in 1873 just about the same; to-day it is approaching 20,000,000 tons per annum.

*Presidential address, delivered before the Iron and Steel Institute, at Barrow-in-Furness, England, Sept. 1.

The product of steel, nearly 15,000,000 tons, is greater than the rest of the world.

The progress of Germany and Britain has also been great. Britain made 643,000 tons of steel in 1874, and last year 1,826,000 tons. Germany made 362,000 tons in 1874, last year 6,394,000. In 1874 Britain made 6,054,000 tons of pig iron, Germany 1,906,000 tons. Last year they made 8,518,000 and 8,403,000 tons, respectively. In 1874 the world was producing nearly 14,000,000 tons of pig iron and 280,000,000 tons of coal. Now there is being produced 41,000,000 tons of pig iron and 780,000,000 tons of coal.

Another item—Mr. Forbes is informed that for the last seven months natural gas had been utilized in Pittsburg in one of the mills. The largest output for a furnace then known was during the week ending Sept. 7, 1874—702½ tons, 100 tons per day. When our Lucy Furnace made 100 tons in one day the world thought the limit was surely reached. Two new Carnegie furnaces have recently averaged 650 tons each per day for months at a time.

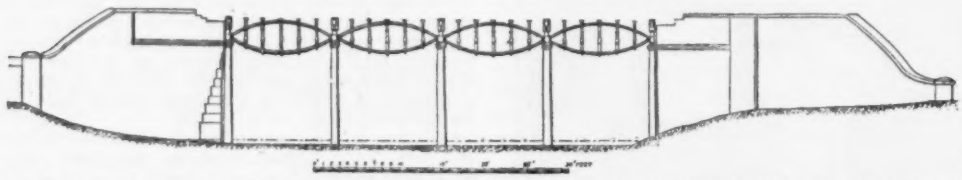


FIG. 1. DIAGRAM ELEVATION OF IRON RAILWAY BRIDGE BUILT IN 1823 FOR THE STOCKTON & DARLINGTON RY., ENGLAND.

Records are given of various enterprises which promised brilliant results, but which are already things of the past. Perhaps the most noticeable point of all is that not the slightest mention is made of the Carnegie Steel Company—so much a thing of yesterday it is. It was making iron and building bridges and had also furnaces in operation, which were visited by the late Thomas Whitwell, but it was scarcely worth noticing, as its steel works were then only under construction. So rapidly do things grow in the new land!

You have noticed that the blast furnace product increased more than six times, and also the rail mill's product about the same. The work of a week is now done in a day, but great as is that contrast, here is one still greater. There have been made and sold without loss hundreds of thousands of tons of 4-in. steel billets at 3 lbs. for a penny. Surely, gentlemen, the limit has been reached here. I think it has, and it is doubtful if ever a lower price can be reached for steel. On the contrary, there is every indication that period after period the price of steel is to become dearer owing to the lack of raw materials. To make that 3 lbs. of steel, at least 10 lbs. of material were required—3 lbs. of coke, mined and transported 60 miles to the works, 1½ lbs. of lime, mined and transported 150 miles, and 4½ lbs. of iron stone, mined at Lake Superior, and transported 900 miles to Pittsburg, being transferred twice, once from cars into the ship, and again from the ship into the railway cars. How it was done I cannot pretend to tell you, but I know the figures are correct. But every time I repeat them I doubt their possibility. This was done during the day of depression, when everything was at the lowest. Costs are several dollars per ton higher to-day, during this period of boom in America.

Gentlemen, such is the contrast between 1874 and 1903. What is it to be 29 years hence? What changes are to come? I have tried to imagine some of its features. It is scarcely possible that this country can increase its product of iron and steel materially. Let us hope that the product will not be decreased. The vital element in the matter is, as we all know, the supply of iron ore. Many of you are conversant with the situation here. I only know what I learn from others, but undoubtedly the attention of the iron and steel manufacturers should be directed to this question, Where and how can they obtain a supply of iron-ore?

Nor is it a question which the manufacturer of America can safely neglect. It was because it forced itself so strongly upon us that we secured such an abundant supply of the best ore obtainable. For 60 years, I think, the United States Steel Corporation are supplied at their present rate of consumption; but 60 years is as nothing in the life of a nation. It is upon future discoveries of iron ore that the future of cheap steel manufacturing, even in America, depends. There are immense deposits in now inaccessible parts. In Utah, for instance, and in Southern California large deposits have been found, so that steel will continue to be manufactured, but it would not surprise me if its cost was very greatly advanced in the future. It seems almost miraculous that such an article as steel could be produced and sold without loss at 3 lbs. for a penny. I am convinced that this is a thing of the past. It will be a question of increased cost and therefore of increased price, so that neither Britain nor American need fear that steel manufacture will be wholly lost; the world will gladly pay the increased price necessary to obtain it. During the next half century, it seems that America is to increase her output at a tremendous pace. The output of Britain will perhaps remain stationary or even increase somewhat if developments in Norway and Sweden prove satisfactory.

Gentlemen, even if this Barrow meeting should fail to rank in importance historically with the first one, I am sure that in the warmth of welcome received, in the enjoyment of the occasion and in the meeting of one with another, the records will not fail to show that 1903 compared favorably even with its epoch-making predecessor.

THE FIRST IRON RAILWAY BRIDGE; STOCKTON & DARLINGTON RAILWAY, 1823.

We illustrate in the accompanying sketches the general construction of probably the first iron bridge built for railway traffic. This bridge was built in 1823 and carried the line of the Stockton & Darlington Railway over the River Gaundless, a tributary of the Wear, near West Auckland, then St. Helen's, England. Until 1842 this bridge was used to carry the main line traffic of the railway, but during that year the completion of the Shildon Tunnel changed the main line of the road and left to the old line only the ore traffic of the vicinity, which the bridge illustrated continued to carry for many years. It was, however, finally abandoned for this purpose also, and has not been used at all for a considerable period of time. Recently the mineral traffic of the district has increased to such an extent that the Northeastern Railway, which has operated the original Stockton & Darlington line since 1863, decided to replace the old structure with a modern girder bridge of steel.

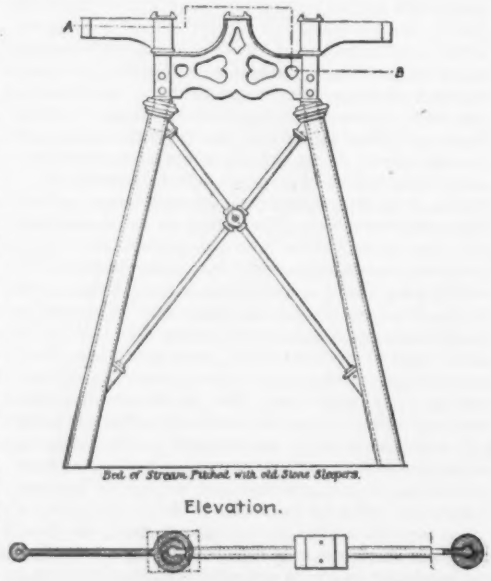


Fig. 2. Cast-Iron Trestle Built for Stockton & Darlington Ry. Bridge.

The general appearance of the old bridge is quite well shown by Fig. 1, and some of its details will be seen in Fig. 2. As will be observed, the bridge was carried by five bents, each composed of two cast-iron legs with X-bracing between them. These bents were spaced 12½ ft. apart, and the spans of the girders were thus 12 ft. 6 ins. Each girder was composed of two curved members of wrought iron, separated by cast-iron verticals, which were cast around them. At the ends where the curved members joined, iron bosses were cast around them and provided with a sort of tenon or spigot, which set into the legs of the cast-iron bents. These bosses were also grooved so that a cross frame of cast iron fitted into them over each bent. These details are clearly indicated by Fig. 2.

According to "Engineering" of London, from which we take the facts of this description, it is believed that this bridge was built from designs by George Stephenson, but a Mr. Storey is credited with its erection.

ANNUAL MEETINGS OF THREE NATIONAL STREET RAILWAY ASSOCIATIONS.

The famous watering-place and convention town, Saratoga Springs, N. Y., was during the past week the place of meeting of three societies concerned with street railway matters. The most important of them, the American Street Railway Association, is the 21-year old parent of the other two: the Street Railway Accountants' Association of America, and the American Railway Mechanical and Electrical Association. The last-named organization is less than a year old, but the Accountants' Association has existed since 1897, holding its meeting each year at the same time and place as the parent society. The three allied conventions extended over the four days from Tuesday, Sept. 1, to Friday, Sept. 4, inclusive. Headquarters were established at the Grand Union Hotel, in whose large courtyard and piazzas the supply men displayed their exhibits. Over 500 members and guests attended the conventions.

The American Street Railway Association, whose active membership is composed of over 200 street railway companies and which aims to fill a place similar to that occupied by the American Railway Association, held three sessions during the convention, the opening session on the afternoon of Sept. 2 and one on each of the following two mornings. As only the last of the three sessions reached the length of three hours, the actual work done by this association during the convention was less in quantity than is usually thought appropriate for such an expensive and pretentious meeting.

The Accountants' Association also held three sessions, opening on the morning of Sept. 2 and continuing on the two following mornings. The American Railway Mechanical and Electrical Association began its meeting a full day earlier than the other two societies, but as its other sessions were held on the mornings of Sept. 3 and Sept. 4, respectively, its meeting as a whole overlapped with those of the other two societies to such an extent as to make the three conventions in effect simultaneous. It thus became impossible for a delegate to follow the sessions of more than one of the three, a disadvantage felt most seriously by the newest and smallest society. This was recognized by the "mechanical and electrical" men to the effect that they concluded to begin future annual meetings two days before those of the other societies, in order that their work may be over before the others get into harness. In this connection we should also mention that many members of the American Street Railway Association were dissatisfied with the short time which the program allowed for the society's technical meetings, and steps were initiated to remedy this on the occasion of future meetings by a greater number of sessions.

Before summarizing the technical proceedings of the three associations we may refer to the entertainment features of the triple convention. The real season at Saratoga, the racing meet, had closed a week before, so that the street-railway people had almost complete possession of the town. Excellent weather favored the societies, so that the three excursions provided as entertainment were generally enjoyed. On the evening of Sept. 2, virtually the first day of the meeting, the delegates were taken to Saratoga Lake, five miles east of the village, where a vaudeville entertainment and a dance took place. On the following afternoon the General Electric Co. carried the delegates to its works at Schenectady, thirty miles south of Saratoga, and after serving an elaborate feast to the 500 visitors escorted them on a brief inspection trip through portions of the vast plant. For the last day of the meeting, Friday, a trip to Lake George, some thirty-five miles to the north, over the Hudson Valley

(electric) Railway was provided, by courtesy of that company, with a dinner at the lake and return trip in the evening. In addition to these general excursions there was abundant opportunity for other trips of interest to street-railway men. A network of electric railways forming the Hudson Valley Railway Co. centers at Saratoga, extending fifty miles north to Warrensburg, on Lake George, and almost as far south to Albany and Troy, running through a great number of important manufacturing towns. Within reach of this line, on the upper course of Hudson River, is the great water-power plant at Spier Falls, of which a full description was published in a recent issue of Engineering News. Two important electric interurban lines, the Schenectady Ry. and the Albany & Hudson Ry., are also in easy reach from Saratoga. The mineral springs of Saratoga, described in the welcoming address of Senator E. T. Brackett as being of such variety that they are "suited to any condition of stomach, or bowel, or kidney," must also be remembered as part of the attractions offering to the visitor.

The technical proceedings contained many points of interest, but in general have not the scientific or technical value which belongs to the work of the national engineering organizations. The following report is therefore a very condensed summary of the work.

American Street Railway Association.

In the absence of the president, Mr. J. C. Hutchins, the first vice-president of the association, Mr. W. C. Ely (International Railway Co., Buffalo, N. Y.) presided over the meeting. At the opening of the first session, following a welcoming address, delivered by Hon. E. T. Brackett, of Saratoga Springs, Chairman Ely read the annual presidential address, in which he reviewed some features of recent electric railway development and made a number of suggestions concerning the work of the association. A noteworthy suggestion was that standardization of equipment and operating practice on electric railways was a necessary development of the future, which standardization should make use of the principles evolved in steam railroading, and that the sooner it is reached the better it will be for the street railway business. He also suggested that changes in the association's methods of works were desirable, to secure more valuable results from its meetings; in particular the "reliance on the good nature and generosity of local companies for free entertainment" was deplored by the speaker.

The report of the Executive Committee and that of the secretary and treasurer followed; the latter reported twenty new members, making a total of 206 companies, and $10,000 in bank—a prosperous condition.

COMPENSATION FOR CARRYING MAIL.

This matter was brought up for discussion by Mr. J. Grant (St. Louis, Mo.), who complained that the rates now offered by the U. S. Government are unprofitably low. He desired that a committee of the association should confer with the Postmaster General and with the Congressional committee controlling the appropriations for carrying mail on electric cars, with the object of securing higher appropriations so that reasonable compensation can be secured. Discussion on the matter showed that many companies are in the position of refusing or discontinuing mail contracts because of inadequate rates; this applies to interurban roads as well as to city lines, and the former are rapidly becoming an important factor in the rural delivery system. The following resolution was offered by Mr. Grant, and was adopted by vote of the association:

> Resolved, That the president of this organization be empowered to appoint a committee of three to confer with the Postmaster-General in relation to compensation for the carrying of mail by interurban cars for mail in pouches, and mail cars in cities, said committee to enter upon its duties forthwith and report to the secretary of the association immediately upon the completion of the work.

A committee having substantially the same purpose was in existence some years ago, Mr. H. C. Payne, the present Postmaster General, having been one of its members. No report was ever received from that committee, but the opinion was expressed that at the present time better results might be expected.

STEAM TURBINES AND GAS ENGINES.

The second session opened with a paper on "Steam Turbines," by Mr. W. L. Emmet (General Electric Co., Schenectady, N. Y.). Its main feature was the announcement that the 5,000-KW. Curtis turbine unit built for the Commonwealth Electric Co. of Chicago had been installed and has been run through a series of tests. The machine was started without hitch and operated well under all load conditions up to full load, governing within 2% speed variation. Elaborate steam consumption tests were made, but were seriously vitiated by the flow of circulating water into the steam space of the condenser through a misplaced valve. The machine will go into regular service in a few months. This is the third turbine of the Curtis type put into commercial operation up to the present, the first being a 600-KW. horizontal-shaft machine in the lower plant of the General Electric Co., and the second a 500-KW. vertical-shaft machine in the power plant of the General Fall River Street Railway Co. at Newport, R. I. The former machine has been running for two years, the latter since June, 1903, in daily service. These machines have been fully successful in operation. A condenser is now being developed which will form part of the turbine base for Curtis machines With steam turbines the condenser vacuum is a very important matter; a very high vacuum is essential to good steam economy.

Discussion on this paper dealt largely with the possibilities of the gas engine. Mr. J. I. Beggs (Milwaukee Electric Ry. & Light Co., Milwaukee, Wis.) stated his strong belief that the future would show the steam turbine to fall behind the gas engine as the reciprocating steam engine is falling behind the turbine. This opinion was not generally shared. Mr. C. O. Mailloux (New York, N. Y.) cited three cases where he had calculated the relative advantages of steam turbine and gas engine installation. Only in one case, a mine-pumping plant in an inaccessible place, did he recommend the gas engine plant. In the others the much greater first cost of the gas engine plant, even aside from the matter of floor-space and foundations, had much more than neutralized any possible operating economy that could be claimed for it. Mr. Emmett, in replying, said that the actual performance of gas engines under working conditions did not exceed that of steam turbines; moreover, as he put it, "the gas engine is a gasoline automobile on a large scale, whereas the steam turbine is as simple as an ordinary grindstone."

Some statements having been made in the discussion which the speakers did not desire to see reported in the "Proceedings" or in press reports, there was much debate over the question of revising stenographers' notes before publication. In the face of a ruling by the chair against such revision, the matter was referred to a special committee. At the following session a report of this committee was received and adopted. According to these resolutions, at future meetings the chair shall appoint a committee of three to edit all stenographic notes before they are issued to press representatives; in case anything is said in discussion which the speaker desires to withhold from publication, it is to be considered a privileged communication; every speaker shall have opportunity to revise the report of his discussion before it is printed; and, finally, the technical papers shall be requested to refrain from issuing daily reports of the proceedings of the previous day. The latter clause had reference to one or two technical journals which (as in past years) made a feature of issuing daily numbers during the meeting. With these restrictions on undue publicity the association considered that members would feel more free in discussion, so that the interchange of ideas would become more complete and valuable.

The gas engine discussion had one other result worthy of note: A resolution was introduced by Mr. Beggs, and adopted by the association, that for the meeting of next year efforts be made to secure "papers from prominent and experienced manufacturers of reciprocating engines, manufacturers of steam turbines, and the manufacturers of gas engines, as to their respective merits."

On the closing session of the meeting most of the papers scheduled on the program were disposed of by title and without discussion. It should be mentioned that most of the papers presented to the meeting were not due purely to the initiative of their authors, but constituted special reports on subjects assigned to the authors six or eight months ago by the Executive Committee. As might be expected, many of the papers show traces of this in the way of labored or perfunctory treatment.

Mr. Richard McCulloch presented a paper on "The Production and Distribution of Alternating Current for Large City Systems." This is essentially a summarized statement of most recent practice in large steam-power alternating-current central stations; in addition it contains a table of data on the power systems of electric roads in all cities over 100,000 inhabitants, and at the end is given a comparison of the advantages of direct-current and alternating-current production for street railways. The conclusion of the author is as follows:

> In some of our largest cities, where heavy loads must be taken care of at long distances from the central station, or where the central station cannot be located near the center of the load, or where reasons exist, such as cheap coal, water transportation, etc., for locating the central station away from the center of load, alternating current distribution from a central station will probably be found the more economical; but if a location for an economical power plant may be obtained near the center of load, and the total city load is comprised within a radius of five miles from this point, as is the case in most cities of less than 250,000 inhabitants, it is probable that direct current generation and distribution from this central station will prove the more desirable. Where doubt exists, preference should be given to the direct-current system on account of its greater simplicity, unless there is likelihood of a great expansion of the system in the near future, when direct current transmisssion might prove burdensome. In case the direct-current system is adopted, suburban lines too long or too heavy for 500-volt transmission may be supplied by alternating current generated in the power plant for their use, or by means of boosters. If the suburban lines are of moderate length or if they require normally only a small amount of power, and make unusual demands upon the power plant only at intervals, such as on holidays and pleasant Sundays, which is the condition on many suburban roads, these lines can best be taken care of by means of boosters, and the same boosting system may be useful in operating some of the city lines. A company which installs an alternating current transmisison system on its heavy city lines merely to furnish power for a few light straggling suburban lines more economically, would place itself in the illogical position of allowing the tail to wag the dog.

The paper was read by title only and was not discussed. The same is true of the next paper scheduled, a paper on "Maintenance and Champerty in Personal Injury Cases," by Mr. M. Brennan (Detroit, Mich.). This paper scored the practice of conducting cases, for persons injured in an accident, on a share of the damages collected. Any such practice was prohibited entirely under the English common law, and the author advocates putting this prohibition into practice again. Incidentally he referred also to the conditions surrounding "expert testimony" and cited the methods used in various countries to ensure impartial testimony.

Mr. C. A. Coons (Buffalo, N. Y.) in a paper on "Train Orders and Train Signals for Interurban Roads" described a train-order blank modeled after those in use by steam railroads but involving certain differences in practice. He also described the dashboard markers and lamps used on the International Ry., of Buffalo, to designate car following, run number, etc. These signals or "flags" are preferable to flags as used on steam railways because they are more easily seen and made out at a distance. There was no discussion.

FREIGHT AND EXPRESS ON ELECTRIC RAILWAYS.

A paper under this title by Mr. J. B. McCleary (Birmingham, Ala.) provoked some discussion. The paper is reprinted in abstract on another page of this issue. It was the general opinion that the subject is only beginning to become important, and that it will be worth discussing at future meetings of the association. It seems that at present little information is available on the earning power of express service on electric railways, and even much less on the matter of the expenses of the service. In many States, of course, there are statutory obstacles which prevent electric railways from hauling goods of any kind, as in the case of Wisconsin, cited by Mr. Beggs (Milwaukee). In considering the value of express service, the net earnings are not the only thing to be kept in mind; at Binghamton a line

about 10 miles long to a smaller place operates an express service, which is farmed out to an express contractor for a fixed sum. The company considers the main value of this service to be its effect of developing the country along the line. A figure on income and expenses was given by Mr. Allen, who stated that on the Utica & Mohawk Ry. three express cars are operated, with a system of teams at each end of the line for delivering and collecting; the gross receipts are about $3 per car-hour, and the expenses take about 70% of this, leaving about $1 per car-hour profit. The situation in regard to express service was summarized by Chairman Ely, who asserted that many managers had approached the question like schoolboys, and that the proper relation between service and expenses was rarely considered. Some of the best working cases of express service make no money because the expenses eat up the income. When the business is taken up extensively the added expenses in the way of station-masters, etc., become so great that there is no profit. He also stated that steam railways strongly discourage freight and express service on electric railways, and in some cases absolutely refuse to exchange traffic with them.

A short paper by Mr. H. H. Vreeland (New York, N. Y.), entitled "The Right of Way," brought up the subject of regulating vehicular traffic in streets. The paper is as follows:

It has always seemed to me, when the question of the right of way of street cars has been under discussion in our societies, that it has been approached from the wrong point. This defect in the discussion seems to arise from a lack of clear statement of what is meant by "right of way." Street railroads, in the sense that steam railroads enjoy this privilege, have no "right of way." A steam railroad operates along a strip of land, owned in fee, which it holds and uses for its special purposes against all intruders, and it can only be obstructed by trespassers. The case of a street railway is entirely different. It has a franchise to go along a rigid and appointed route on thoroughfares which are used in common by pedestrians and vehicles of every description.

This being the case, the question of "right of way," in so far as it is applicable to street railroads, becomes one not of right of way but of precedence, since the general public has equal rights on the road. These roads or streets being dedicated to public use, it is the duty of the authorities to see that they are so policed as to obtain for the greatest number of people the fullest and freest use of the facilities which they afford. If street railroad men would view the topic from this point of view and insist that the streets are for the use of the people instead of corporations or individuals, the whole question, in a short time, would take on a different aspect. A railroad company is permitted primarily to exist, not for the aggrandizement of its owners or operators, but for the accommodation of the public. An individual citizen who enters and pays a fare does not thereby relinquish any of his rights to free passage along a public street, and there is hardly an hour of the day or night in which he can enter a car on a street anywhere in a city without finding company, so that the vehicle in which he rides represents not only his individual right, but the assembled rights of all his fellow passengers; and so it has always seemed to me, viewing the question from the standpoint I have indicated, that a crowded car, full of people, should, by mere preponderance of the number of individuals it contained, have a superior right of passage to a vehicle with a single individual in it, or to a van containing merchandise. If, before public bodies, it was unanimously insisted by railroad men that the reason they demanded "right of way" was because of their passengers, I think it would disarm much of the resistance which has met the attempt to secure police co-operation.

A good analogy between the rights which all street railroad operators claim for their vehicles is to be found in the rules of the road concerning United States mail vans. These have the right of way everywhere, and it is a misdemeanor to obstruct their free movements. The reason of this is not because the wagon is labeled "United States Mail" or because of any superior authority vested in the driver, but because the vehicle contains hundreds—it may be thousands—of business communications involving complicated business interests. For the same reason, I have always held that a street car containing a crowd of people, necessarily in haste or they would find a cheaper and more leisurely way of reaching their destination, had rights superior to other vehicles on street surfaces.

Added to all this is the fact that these public conveyances are restricted in their movements to a fixed way, whereas the others, in addition to being lighter and more easily moved, have a flexibility of route denied to tramcars.

The author elaborated the subject at length with reference to the conditions of traffic congestion existing in New York City last winter, and how he secured a great improvement in the movement of traffic by drawing public attention to the delay suffered by street-car passengers when the car was blocked or delayed by wagons or other obstructions. Mr. J. G. White (New York, N. Y.) said that European cities were much ahead of us in regulating street traffic, and suggested that a study and tabulation of foreign regulations might help American lines to secure valuable public regulations on vehicle traffic. Mr. W. C. Ely (Buffalo, N. Y.) called for an education of school children in road and street regulations, to teach them to avoid wagons and cars, cross streets at regular crossings only, etc. In Nuremberg, Germany, it is a criminal offense to attempt to get on or off a moving car, and a similar ordinance was recommended for American cities. In Milwaukee, according to Mr. Beggs, the street railway company secured valuable results by personal appeals to the employers of many teams, as breweries, ice companies, etc., who were found quite willing to aid in preventing their wagons blocking the street car tracks. That regulations and laws alone are not sufficient was illustrated by Mr. J. Grant, who said that in St. Louis the police department had been unaware of the existence of a law compelling teams to turn out immediately before a car. By informing them of this law, and by personal appeals as in Milwaukee, the conditions in St. Louis have been much improved.

The subject of "Single-Truck and Double-Truck Cars for City Service" was informally discussed by Mr. J. I. Beggs (Milwaukee, Wis.), in a statement of the advantages of the double-truck car. The smoothness of riding and the higher acceleration possible with four-motor equipment securing higher schedule speeds and better headway, are the main advantages of two-truck cars. After several years' experience in Milwaukee, where now only two-truck cars are in use, it is found that track repairs and maintenance are much lower than when single-truck cars are used.

It was suggested by Mr. W. C. Gotshall (New York) that the association appoint a standing committee on legislation and another on standards. The former committee would be of value in keeping the members informed of regulations made by various States and cities and would thereby help to secure better regulations everywhere. The proposal was favorably received, but as the by-laws do not permit of standing committees the subject was finally referred to the Executive Committee.

An extended report was submitted by the Committee on Rules for the Government of Employees. The first part of the report gives a code of rules for employees on city lines, while the second part gives additional rules for interurban lines and a code of lamp, flag and whistle signals. This second part of the code was patterned closely after the rules adopted by the American Railway Association. In presenting the report the chairman, Mr. E. G. Connette (Syracuse, N. Y.) made the recommendation that on interurban roads there should be as little variation as possible from a schedule of uniform headway; instead of changing headway to suit varying traffic demands it is preferable to vary the number of cars per train. This recommendation did not meet with general acceptance. The report itself, however, was received with great favor, and a number of the members declared their readiness to adopt them at once for use on their lines. Some individual rules were criticised, and others were found to be modified by local conditions. The report was finally adopted, with the recommendation that all members put them into use as soon as practicable. Deviations from the code may be made to suit local conditions, the present rule-numbers being preserved. The committee was continued for the coming year.

A resolution was introduced by Mr. Beggs, and adopted by the association, that a committee be appointed to confer with the Steel Rail Pool to secure a reduction of the extras charged for high T-rails (other than Am. Soc. C. E. section) and girder rails. The extras now charged are, according to Mr. Beggs, no longer warranted, as there is a great market for such rails from the enormous mileage of electric railways in operation or under construction, and the high rates act as an obstacle to the full development of street railways.

The election of officers for the coming year took place on the last day of the session, the ticket presented by the Nominating Committee being elected on unanimous ballot. Mr. W. C. Ely, of the International Ry. Co., of Buffalo, N. Y., was elected president, and Mr. I. C. Pennington, Chicago City Ry. Co., Chicago, Ill., continued as secretary and treasurer.

American Railway Mechanical and Electrical Association.

The meeting of this society, as already noted, was the first regular meeting since its organization. The society proved to be in a strong working condition. According to the secretary's report there are over 80 members enrolled, and about $500 in the treasury; the papers presented were written by practical men and were well discussed.

After a welcoming speech by Mr. J. P. Brennan, of Saratoga Springs, the presidential address was delivered by Mr. Thos. Farmer. The most important part of this address was its recommendation that the association take up the standardization of electric railway equipment, as a matter of much moment to the industry at large and the mechanical department in particular.

The technical program was opened by Mr. C. F. Baker (Boston Elevated Ry. Co., Boston, Mass.), with a paper entitled "Care and Maintenance of Car Bodies." The author advocated full specifications for car building work, particularly for such detail points as give rise to trouble in service. He then outlined the method of inspecting and overhauling cars of the Boston Elevated Ry., where each car goes over the pit every third day. Car cleaning and painting was treated in detail. The discussion which followed the reading of the paper was quite extended, much of it dealing with painting and washing of cars. An interesting feature of the discussion was that part of it dealing with car wiring. The use of asbestos was strongly condemned by some, because it gave trouble by heating and sometimes setting fire to the woodwork, especially around electric stoves, while, where exposed water, under the car, it absorbed a great amount of moisture. The opinion was expressed that improvement in car wiring should be the aim of every company, more for its own interest than to satisfy the underwriters. Placing the main cables above the floor or in similar protected position was recommended, also using stranded conductors for lamp and heater circuits, etc. Metal conduits for the wires were apparently not regarded with favor.

This paper and its discussion occupied the entire morning session. The second session, held on the afternoon of Sept. 1, began with a paper on some features of street-car motors, which we abstract herewith:

IMPROVEMENTS IN STREET CAR MOTORS.

By E. W. Olds.*

Many of us remember when the first street car motors were put into successful operation—the old Sprague No. 6 and the Thomson-Houston F-20 being wonders of their day, the Sprague equipped with Sprague controllers, and Thomson-Houston with the so-called rheostat, coffee mill. With them, we were able to haul a 14 or 16-ft. car with an eight or ten bench trailer at a speed of 5 to 12 miles per hour. We remember the trouble caused by burning out of controllers, breaking of rheostat cables, also short circuiting and burning out of brush holders, armatures and fields, caused by water and the picking up of wires, etc. We now have reliable equipments, all motors being constructed practically waterproof, with the gears entirely inclosed and well lubricated (except where the gear cases are broken or out of order). The controllers are practically all series-parallel and are giving good satisfaction.

One of the weak points being covered by the manufacturers and railway companies in their special machines is the construction of the motor frame to make it more accessible for inspection and repairs. Nearly all motors as now designed are arranged to open at the bottom, doing practically all of the repair work in the pit. In repairing double truck equipments, it has been found more satisfactory to lift the car body from the truck, making it possible to do all the repair work from the top. To do this, the top half of the motor frame should be designed to

*Superintendent of Rolling Stock, Milwaukee Electric Railway & Light Co., Milwaukee, Wis.

lift off, giving access to the armature, bearings, fields, brush holders, etc.

The dimensions of gears have not been increased in proportion to the motors, as they show excessive wear, causing, very often, the swedging of the teeth. This should be remedied by making the gears with wider face. The quality of the steel should be better; that is, closer grained, and tough, thereby increasing the life of the gear with but little additional cost. The life of our present gears is from 18 to 24 months and of pinions from 12 to 18 months. This should be doubled. The advisability of using split or solid axle-gears is an open question, each style having its advantages and disadvantages. If split gears are used, the bolts should be made larger and provided with nut locks, double nuts and cotters, making it impossible for them to become loose and fall out.

The gear case should be so constructed that it would stand abuse as well as use. To make such a case, I believe it would be necessary to cast it as a part of the lower half of the motor frame, doing away with bolts and giving the gears absolute protection.

The armature bearings should be made longer and larger, with linings that may be easily removed and either re-babbitted or renewed. This would, we believe, make a saving of 50% in our bearing expense. Their lubrication, also, is a very important matter. Until recently, nearly all of our motors have been designed to use grease. Some manufacturers have used both grease and oil, feeding the oil with a wick from below and grease from cups above the bearings. Bearings have been designed to use only oil, to be fed through wool waste or wicks placed in oil wells below the bearings, both of which have been found very satisfactory.

Upon comparing notes with other master mechanics, I find that a great many of them are using a cheap grade of babbitt. My experience is that the best is not good enough. We should have a metal that is hard, tough, and close grained. Our motors must necessarily run more or less in the dust, the soft or open grained metal will hold the small particles, thus causing excessive wear of the shafts. The average life of bearing linings on our city cars at present is about six months. It should be increased to not less than one year. On interurban cars, the average is about eight months, and should be increased to eighteen or twenty-four months.

The contact between commutators and carbon brushes should certainly be improved. This can be done by making the commutator bars longer and deeper, giving better contact with the brushes, and longer life. The best manufacturers do not produce a carbon brush that is always reliable, the brush being, very often, either too hard or too soft, which makes poor contact and causes the commutator to become rough and black, thereby causing the motors to become overheated, burning out the armatures and fields. A better connection should be made between the carbon brushes and brush holders.

One of the weakest points of our motors is the insulation of the magnet wire used for fields and armature coils. There have been a great many experiments made to find a satisfactory substitute for the cotton covering, but nothing better has been found. After all the skill and thought that has been put upon our motors to make them perfect, mechanically and electrically, it seems too bad that we are obliged to use the same cotton covering we did years ago, as their electrical life depends, to a very great extent, upon our being able to produce an insulation that will not carbonize.

The discussion of this paper was quite extended, but contained nothing of general interest.

A paper on "Shop Kinks" was read by Mr. H. H. Adams (United Railways & Electric Co., Baltimore, Md.). Various special devices were described in this paper; a simple sand-blast apparatus for making ground glass, a gallows-frame hoist for unloading cars from railway cars, a cradle-cart for handling armatures, etc. The discussion brought out descriptions of some other "kinks" which are used in various car shops. Very similar was a paper on "Shop Practice" by Mr. A. Green (Rochester Ry. Co., Rochester, N. Y.), who, in describing the car shop of his company, brought out the special rigs used to carry on car-repair work. The general arrangement of the shop is the following:

The shops have a frontage of 186 and a depth of 191 ft., being divided into three parts by walls at right angles with the front of the building. On the north side are the carpenter and paint shops, on the south side the motor repair and machine shops, the center being occupied by the office and store room, with the blacksmith shop at the rear. A door leads from each department into the store room; a very convenient arrangement. All orders for material are signed by the foremen of the various departments, and are filled by the stock-keeper. The store room is 26 ft. wide and 143 ft. deep. All necessary equipment for the entire system is kept in stock, the small material on the ground floor and the heavy material in the basement. The basement is also provided with a large room for the storage of car wheels, extra motors, controllers, etc., and is equipped with a narrow-gage track and overhead travelers for the handling of heavy machinery. All departments are piped for compressed air, for use in hoists, drills, etc.

The discussion of the paper turned largely on car inspection. A regular inspection of field coils and armature bearings is particularly important. Bearings are often rated by car mileage, being renewed or at least thoroughly examined after the car has made a certain number of miles. This is often unsatisfactory, however, as great variations occur in the mileage of similar bearings on various tracks or on different routes, even when the motor is of the same type. Daily inspection of the entire car equipment was considered highly desirable where possible.

"Train Control" was treated in a short paper by Mr. W. O. Mundy (St. Louis Transit Co., St. Louis, Mo.). Three systems of electrical control of trains of more than one car have been used in this country,

Namely, the Sprague pilot-motor control, used on the South Side Chicago, Boston Elevated and Brooklyn Elevated; the Westinghouse electro-pneumatic control, used on the Brooklyn Elevated and several small installations, and the General Electric "Type-M" control, used by the Manhattan Elevated, and adopted by the Interborough, both of New York; the Aurora, Elgin & Chicago, and a large number of others.

Taking these three in order, I find that since the Sprague company has been absorbed by the General Electric Co., it is no longer pushing the pilot-motor control; and, in fact, the Sprague company, before the consolidation, had proposed and was advocating a scheme somewhat similar to the contactor system. Thus we can safely drop the pilot-motor control from our discussion, considering it as not being up to date.

Referring next to the Westinghouse electro-pneumatic drum control used in Brooklyn, we find that the company is no longer advocating this, but has only recently come upon the market with the so-called Turret controller. However, upon investigation, I find that the company is not ready to give to the public details of the system, and we are, therefore, compelled to drop it from our considerations to-day.

The "Type M" system consists of a number of individual switches on each car, magnetically operated under control of a master-controller having circuits carrying only small currents. With the heavy motor equipments used on very large cars the ordinary hand-operated drum controller is not fully satisfactory, because it is so heavy that it moves too slowly and gives trouble due to the heat of the arc. The "Type M" control, with its individual switches, has light moving parts and breaks the arc rapidly, so that it is suited for the heaviest currents. On this account the author considers that it will be adopted for heavy single cars, even where no train operation is contemplated. The contact tips of the switches give no particular trouble from wear, showing little more wear whether operated with or without current on. Mr. E. W. Olds reported that 25 interurban cars in Milwaukee are now fitted with this control apparatus, the cars having four motors of 60 HP. each. He reported appreciable burning of the contactor tips, but the apparatus as a whole works very well.

Controlling mechanism was also the subject of the next paper, by Mr. D. F. Carver (Public Service Corporation, Jersey City, N. J.), who spoke on "The Use and Abuse of Controlling Mechanism." The paper was a reminder that controllers should be given as much maintenance attention as any other equipment, because they have been developed to the point where future changes will be only in minor points. The controllers should be systematically inspected, looked over several times a day, if possible, and the contacts lubricated. The injurious practice of running rapidly over the intermediate notches between on and off is very common and should be suppressed. The use of automatic devices limiting the rate of motion of the handle is apt to lead to the practice of controlling by the brake, leaving current on the motors. This is very hard on the equipment and very expensive in current. In discussion several members reported various troubles with controllers due to improper operation, for instance, using the reverse handle to make a quick stop. The opinion was expressed that the instruction of motormen should be as thorough as possible, so that they would be able in an emergency to use the motors as electric brakes, etc.

The meeting concluded with the election of officers. Mr. E. W. Olds (Milwaukee, Wis.) was elected president, and Mr. W. Mower continued as secretary and treasurer.

Street Railway Accountants' Association.

This society was able to report a membership of 138 companies and an asset property of $2,400. It has steadily grown, in spite of withdrawals due to consolidations of lines into large companies, but the fact was recognized that to be of most influence the society should embrace a much larger proportion of the electric railways of the country. A movement was initiated to also admit certified accountants not connected with street railways to membership in some grade, for mutual benefit.

The technical proceedings were so entirely specialized in interest that we make only a reference to the subjects discussed. The presidential address contained among other things a plea for more correct treatment of depreciation than is generally practiced. The conditions of the financial side of the street railway business, however, often work against proper accounting in this regard.

"Freight and Express Accounts" were discussed by Mr. I. Fullerton (Detroit, Mich.), who described in detail the method of keeping books on the freight and express business of the Detroit United Ry. The system used is quite complete, and the blanks employed are all reproduced in the paper. A special business is made of milk-cans, this company handling most of the milk going to Detroit from along its lines. Some of the difficulties in maintaining a properly working express system on small systems are thus referred to:

The steam roads have some advantages over electric lines. Their consignments are larger; the rates average much higher and their employees have grown up with them. Our earnings do not warrant employing salaried men at some stations. The work is done by storekeepers who are paid a commission. They keep the most primitive accounts of their own business, and it is necessary to make up all their reports, and we are pleased when they are willing to pay cheerfully the amount the reports show due the company.

Besides the oral discussion of the paper there was a written communication from Mr. E. H. Hyman (Cleveland, O.) describing the method of business used by the Electric Package Co., which is the freight and baggage department of four electric suburban lines running out of Cleveland.

A paper on "Car Maintenance Records" was presented by Mr. S. C. Stivers (Edgewater, N. J.). This paper describes a system of book-keeping comprising the following elements:

(1) An individual car record which shows the cost of all repairs, both labor and material, on any one car for any period or mileage; (2) an armature record; (3) a wheel record; (4) a bearing record. The repairs are classified in 14 classes, viz., paint, glass, fender, miscellaneous body, brakes, journals, wheels, miscellaneous trucks, controller, armature and fields, bearings, trolleys, gears and pinions, miscellaneous electrical; numbered from 1 to 14, respectively.

The armature record is used to keep track of the work of the armature repairers and the causes of armature failures. The bearing record gives information about the service obtained from different bearings. The wheel record is to check makers' guarantees on wheel mileage.

Mr. W. M. Steuart, of the Manufactures Bureau of the U. S. Census Office, presented a paper on "Census Statistics and the Standard Form of Electric Railway Accounting." This was a very extended discussion of the diversity existing in street railway accounting through the United States and the difficulties which this fact caused in collecting and arranging the government statistics. The Bureau some time ago adopted the standard form of accounting prepared by this association, and is working to secure its general adoption by individual companies as well as by state bureaus.

The Committee on Form of Report for Electric Railways reported on the progress made during the year in securing the adoption of the association's standard form. This standard form was also the subject of a paper by Mr. C. N. Duffy (Chicago, Ill.), containing a comparison with the proposed standard classification and form of report of the British Municipal Tramways Association.

A paper entitled "Advantages and Disadvantages of the Bag System as Compared with the Receiver System of Handling Conductors' Remittances," was presented by Mr. F. R. Henry (St. Louis, Mo.). The course of business with the two systems was traced in detail in this paper, and a comparison instituted between the two methods.

HANDLING FREIGHT AND EXPRESS ON ELECTRIC RAILWAYS.*

By J. B. McCleary.†

The main idea of the railway business is to make money, and any manager who attempts to operate a line without taking on everything he can find or think of that is permitted by his charter to increase his earnings, is standing in his own light. I sent out about 500 inquiries for data on freight and express handling by electric railways and received 182 replies. Some of the answers to my circular letters were amusing, among them several underscored "No's" in answer to the question "Do you handle freight?" and followed by reasons which would indicate that the parties making the answers had a supreme contempt for the idea. Others would answer that they did not, but were deeply interested in the subject and would await the publication of this paper with much interest. Several requested advance copies of any table which might be compiled from the answers to the circulars, as they were themselves seeking information on the subject.

One enthusiastic manager courteously answered all questions, even to the figures showing his profits, and added, "This is velvet," and his "velvet" amounted to many thousands of dollars. Right here I want our people to stick a pin. It is in the word used by our enthusiastic friend. That it is "velvet" there is no doubt, if you would engage in the business and not let expenses eat it up. There is no excuse for this, for almost under any conditions now known to the fraternity, freight and express can be cheaply hauled on the electric railway, that is of course where it is permitted, or rather not prohibited by charter or statute. Of course local conditions have a great deal to do with this matter. There is only one general proposition in connection with this question, and that is that the people want everything good that can be had. That electric railways can serve the public in transporting passengers to their satisfaction is proof that they can surely serve the same people in hauling freight and express matter, and do it safely and profitably.

Upon investigation of the 182 replies we find that 71 roads handle freight and express, 45 roads admit that it is profitable and that they intend to increase their facilities for handling their business, 37 say that this is a very attractive feature of electric railroading, while 9 answer that while they carry freight, they do not think well of it. Thirty-five roads use the steam railroad classification of their states or railroad districts, others have rate sheets of their own based upon local conditions and generally much lower than the steam railroads. Thirty-eight have depots at terminals and along their lines, and 9 say they have none. Twenty-four are silent on this subject. Eighteen handle steam railroad cars on their line. This is particularly a fine feature, provided the track is good and the special work will allow it. Of course this cannot be done in many cities and towns, but on the outskirts and suburbs, where factories and mills are located, it can be made to pay handsomely. Fifty roads have separate freight cars or trains, 3 have trailers attached to passenger cars, and 8 handle packages on passenger cars. One hundred and eleven answered that they do not handle freight at all. Seventeen of these admit that they believe it should be done, and four of the 111 request information, stating that they are interested in the idea. Compiling our 182 letters we have the following:

Electric railways handling freight and express:		
Profitable	45	
Doubtful	9	
Leased to local express companies	5	
Non-committal	10	
Non-profitable	2	71
Electric railways not handling freight and express.		111
		182

The biggest development seems to be in the middle west. Thirty-seven roads reported the gross earnings from freight and express for 1902 as aggregating over $1,000,000, an average of over $27,000 per road. The operating expenses of the freight department do not seem to be very accurately kept, or at least the same details in accounting are not adhered to as are other features of the business.

The most expensive plan is that of running wagons to collect parcels from shippers and to deliver them to the consignees. We are unable to find that this pays as great a profit as where it is not attempted. In a large city the most attractive plan, it would seem, would be to let a separate express or parcel company do this and pay the railroad company a certain amount for cars or space, or a per cent of the gross receipts and the railroads have nothing to do with it, except to merely haul the goods for the express company. Something on this order is done in St. Louis, Baltimore, Cleveland, New Haven, Portland (Oregon), and New York. Figures, however, that would be of interest to the association are not available from these cities, but it seems to be a safe proposition and everybody satisfied with the results.

*Abstract of a paper presented before the American Street Railway Association at Saratoga Springs, N. Y., Sept., 1903.

†Birmingham Ry., Light & Power Co., Birmingham, Ala.

NOTES ON THE MANUFACTURE OF WELDLESS STEEL PIPES AND SHELLS.*

By Heinrich Ehrhardt.†

The consumption of tubes and hollow bodies of all kinds made of malleable metal is now not only very considerable, but is continually increasing, partly on account of the incapability of cast tubes to withstand a heavy internal pressure, and partly owing to the fact that even where a moderate pressure is employed, the greater thickness of the wall increases their cost much beyond that of tubes made from rolled iron. The latter are still for the most part manufactured from bent plates, the edges of which are joined either by riveting, welding, or soldering, notwithstanding the long-continued efforts of both manufacturers and consumers to do away with such seams and to forge

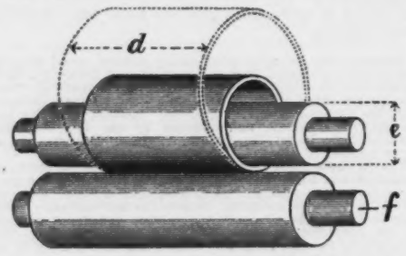


Fig. 1.

and roll the tubes from a single blank. These efforts have been attended with greater success since wrought iron has given place to mild steel as a structural material; the former metal being by nature ill-adapted to withstand the various modes of treatment either in the cold or in the hot state, especially the operations of bending, boring or piercing, and welding, all of which tend to weaken the tube.

Although it may appear a simple matter to pierce and draw out an ingot of mild steel when hot, yet many experiments were necessary before a practical and economical method was discovered. For making tubes of smaller sizes up to 10 or 12 ins. diameter several processes have been in use for the last ten years by which serviceable tubes are manufactured cheaply. Among these the author's own process is one of the best known, consisting of piercing and drawing out billets, by means of which tubes of excellent quality are produced.

A more difficult operation is the manufacture of tubes and hollow bodies of large diameter, such as ring courses for boiler shells, furnace tubes, hydraulic cylinders, etc., in which the abolition of riveted or welded joints is a decided advantage. This problem has only quite recently been solved, previous attempts in this direction having led to no practical results.

For the preliminary operation of piercing the billet, a process patented by Gleichmann proved the most suitable, being possessed of advantages which rendered it essentially superior to the author's own process. The main feature of this method is that the upper end outer surface of the cylindrical billet is pressed against the wall of the die immediately on the entry of the mandril, recesses being formed in the interior of the die by which the billet is firmly held, while the lower portion is pressed forward as the mandril continues to penetrate it. By this means the billet is elongated by about 80 to 90%, and the diameter of the hole is from the first considerably larger than when pierced in the former manner by the old process, which is a great advantage in making large cylinders for subsequent rolling out in a rolling-mill. In some cases a single piercing operation suffices to make a blank of the

Fig. 2.

desired length and cross-section, but long cylinders with thin walls have to be drawn out to the required length before rolling. The second operation then consists in rolling out the ring to the larger diameter with the desired thickness of wall. It is of special importance to give as large a diameter as possible to the inner roll, because in rolling out the shell as shown in Fig. 1 the length d depends upon the diameter e of the inner roll. If the length d of the shell is excessive, the roll which is passed through it will bend on account of the extra pressure upon the rolls necessitated by the too great length of the shell, shown in Fig. 2, which has been patented by the author. Nevertheless, in order to ensure greater accuracy in rolling out the rings it is a great advantage to make the diameter of the roll as large as possible. According to this the lower roll f is made to oscillate during the rolling operation about the central point, so that the pressure is continuously and evenly distributed. In other respects the arrangement of the mill resembles that of a tire rolling-mill, and the rolling out of the rings is performed in exactly the same manner though much more rapidly, on account of the greater power employed, the capacity of the mill being approximately that of any ordinary plate rolling-mill. The cost of rolling is therefore no higher than that of rolling ordinary plates, and since the cost of piercing is also very small, as may be gathered from the previous description, these seamless rings can be more cheaply produced than welded or riveted rings, besides being lighter and of more value on account of their higher tensile strength and general trustworthiness. These excellent qualities have been proved in many trials, and that numerous orders have been given for ring courses for steam boilers, especially for locomotive boilers, and also for other purposes, such as steam and water pipes for heavy pressures, cylinders, and cylinder linings for hydraulic presses, accumulators, and centrifugals, live rollers for rolling-mills, and in short for anything where great strength combined with durability is required.

The Reisholz Forge & Rolling-Mills manufacture single rings by this process up to 8 ft. in diameter and 10 ft. in length.

*Paper read at the meeting of the Iron and Steel Institute of Great Britain, Sept. 1, 1903.

†Dusseldorf, Germany.

THAT MACADAM IS LEGALLY a pavement is the opinion of C. C. Hamann, city attorney of Perth Amboy, N. J. This opinion was given as the result of a petition asking that Smith St. be repaved; and the question that arose was whether the old macadam upon the street was legally a pavement or not. It was argued that macadam is not defined in dictionaries as being a pavement [although the "Century" defines macadam as "macadamized pvement."—Ed.]; but the city attorney has finally given it as his opinion that Smith St. has been paved within the meaning of the law, and that any further paving will be a re-paving, the expense of which can be borne by the city at large.

RECENT PROGRESS IN THE MECHANICAL HAULAGE AND PROPULSION OF CANAL BOATS.

A concise summary of the progress which has been made in the application of mechanical haulage and propulsion for canal boats, is contained in a paper recently read by Mr. Gerald Fitz Gibbon, M. Inst. C. E., of the Aire and Calder Navigation, Leeds, England, before the Engineering Conference of the Institution of Civil Engineers. From this paper we take the following items of most general interest:

Particular attention has recently been directed to electrical haulage and propulsion, and several systems have been tried with more or less success. In France Mr. de Bovet carried out experiments in 1894, on the St. Denis Canal, with an electric motor weighing about 2½ tons, placed on a 300-ton barge. The motor, which was supplied with current at 110 volts from overhead wires on the towing path, actuated a drum which picked up a chain laid on the bed of the canal. The current passed through a cable connecting the motor with a small two-wheel trolley running on the line wires.

The Galliot system, used on the Burgundy Canal in 1894-1897, consists of two parts, the electric tricycle on the towing path, supplied with current from an overhead wire, and the rudder motor. The tricycle weighs 2 tons and is capable of towing two barges loaded with 700 tons at a speed of 1¼ miles per hour. The rudder-motor consists of a rudder forming a closed case containing an electric motor, which drives a screw propeller. The system has also been tried on the canal between Douai and Bethune, where the tricycles towed barges carrying 250 tons to 300 tons, at speeds of 1½ miles to 2 miles per hour. The current was supplied at 500 volts. The cost of haulage is said to be 0.038d. per ton, or about half the cost of horse-haulage.

In Belgium the Gerard system has been in operation since 1900 on the Charleroi Canal, 50 miles in length, which connects the coal fields of Charleroi with Brussels. The haulage used to be performed by horses at a speed of 1¼ miles per hour and at a cost of about 2s. per boat per mile, which seems very high. By electric haulage the speed was doubled, the cost remaining about the same. The boats have a capacity of 70 tons. The annual traffic amounts to about 600,000 tons. The system consists of a four-wheel electric carriage, weighing 2 tons, of about 5 HP. (nominal), the current for the three-phase motor being taken from overhead wires through three separate trolleys. There are in all eight wires, of which three are trolley wires supplying current at 600 volts, three are feeder-wires carrying currents at 6,000 volts, and two are for telephone service. The generating stations are 29 miles apart, and substations, 3 miles apart, contain transformers for reducing the current to 600 volts. Electrically-propelled tugs are also employed, to which the current is conveyed through an insulated cable, supported by a boom on the mast. The tugs tow two boats of 70 tons each at a speed of 2 miles an hour.

In Germany Messrs. Siemens & Halske have experimented with a rack-rail electric locomotive, supplied with current at 500 volts from a single overhead wire. The rack-rail serves as a conductor for the return current.

In England the Gerard system is being tried on the River Lea navigation.

The Thwaite-Cawley system consists of an aerial railway about 10 ft. above the towing path. There are two rails—one for each direction—on which run four-wheel electric motors, two wheels running on the upper surface and two on the lower. The cost of haulage is given as 0.032d. per ton-mile for a speed of 2½ miles per hour.

In Holland, barges propelled by petrol engines have recently been tried with very satisfactory results.